Steep-Slope Cool Roofing

Asphalt Roofing Manufacturers Association

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A "cool roof" is defined as one that uses roofing products with high solar reflectance (the ability to reflect the visible and near-infrared wavelengths of the sun's energy) and high thermal emittance (the ability to re-radiate absorbed energy). Although high reflectance/emittance products are an increasingly popular roof option, they are only one of many approaches to help building and home owners reduce building energy use and address contemporary environmental concerns.

STEEP-SLOPE COOL ROOF OPTIONS

Cool roof options are available for virtually any roof and any building structure, and they can complement other building envelope modifications to accomplish design goals.

Highly Reflective Asphalt Shingles

A combination of proven durability, pleasing aesthetics, and reasonable cost makes asphalt shingles the predominant steep-slope roof covering selected by building and home owners. Asphalt shingles account for nearly 60% of the re-roof market, and comprise 53% of all steep-slope roofing in the United States.[1] The look of asphalt shingles is usually judged to be the same or better than alternative materials such as metal, wood shakes, and clay or concrete tiles. In addition, most asphalt shingles come with an UL 790 or ASTM E108 Class A fire resistance classification, and most are classified by third-party accredited laboratories for wind speeds that allow installation in any jurisdiction within the continental United States, providing the building owner peace of mind.

The dominance of asphalt shingles is continuing in the cool roof arena through development and marketing of highly reflective asphalt shingles. These products maintain a varied color palette that allows customers to match shingles to the design and color scheme of their home while offering the benefits associated with high solar reflectance.

Solar reflectance values for conventional asphalt shingles range from 0.04 for a black shingle to about 0.25 for a white shingle (the original cool roof). The use of granules made with special pigments that reflect most of the near-infrared portion of the solar spectrum has allowed the development of pleasing colors with solar reflectance values that exceed 0.27. Both conventional and highly reflective asphalt shingles have thermal emittance values that exceed 0.85.

[1] NRCA Market Survey, 2015-2016

Various test methods are used to measure solar reflectance and thermal emittance of roofing materials. The ASTM standards listed below are employed to determine the associated properties. Values determined by the various methods are generally similar although not identical.

Reflectance	ASTM C1549, E903, or E1918
Emittance	ASTM E408 or C1371
Solar Reflectance Index	ASTM E1980

It is important to note that the mineral granules used on highly reflective shingles are essentially identical to those which have been used on asphalt shingle roofs for decades except for the incorporation of near-infrared reflective pigments. Use of this proven surfacing material assures consumers that cool asphalt shingles will continue to provide all the benefits they have come to expect from conventional shingles.

Coating of Asphalt Shingles

Coating of asphalt shingles is not recommended by asphalt shingle manufacturers. Application of reflective roof coatings to asphalt shingles may be an alternative option to create a cool roof in some cases, if shingle manufacturer approval and a product specifically designed for use on asphalt shingles can both be obtained. Typical exterior paints should not be used for this purpose.

COOL ROOF LIMITATIONS

While cool roofs may offer immediate and long-term savings in building energy costs, as well as environmental benefits, there are potential drawbacks to consider. Cool roofs may be more likely to show dirt, algae and stains than traditional asphalt shingles due to their typically lighter color and may require cleaning and maintenance to retain their high reflectivity. If not properly performed, cleaning can damage the roofing products. To address this issue, many reflective asphalt shingles are formulated to resist algae growth to help maintain their reflective quality even in humid climates.

Prior to installation of a cool roof, consider the potential effect on adjacent surfaces or buildings that will be exposed to concentrated reflected heat, which can damage surrounding building components, such as plastic, masonry and other rooftop equipment.[2] The same high reflectivity

[2] "A Roofing Industry Professional Shares His Views About Current Issues Facing the Industry,"

may affect occupants of nearby buildings as well by reflecting light into the interior of adjacent buildings.

Another issue is the potential for moisture condensation within the roof assembly. The lower surface temperature of cool roofs reduces heat transmission into the building relative to traditional roofing materials. This leads to an increased risk of moisture accumulation, especially in cooler climates, because there is less heat available to dry out roof assembly materials.[3] "If a reflective cool roof is designed for a temperate or cold climate, its moisture behavior should be analyzed by hygrothermal simulations in order to avoid critical water content in the construction."[4]

Former U.S. Secretary of Energy Dr. Steven Chu has suggested "painting all roofs white" to help offset carbon dioxide.[5] Such a broad generalization can help make a point, but in many cases taking such an action is neither practical nor appropriate and can lead to unintended consequences. For instance, paint can cause premature deterioration of shingles, and for steep-slope applications where aesthetics are an important consideration, white is not preferred by many building owners. There are other means for saving energy within the building envelope, some of which can be more permanent, easier to implement, and more cost effective than roof replacement with a highly reflective roofing material.

CONSIDER THE WHOLE BUILDING APPROACH

The roofing system is a vital component of a building's moisture and thermal barrier and deserves in-depth consideration when developing policy or incentive programs. However, it is only one component of the building. ARMA asserts that the "whole building approach," which considers all elements of the building, internal and external, is the appropriate method to comply with today's green building programs, energy codes, and standards. The selection and use of a steep-slope roof system should be based on the overall building performance, taking into account complete and reliable information about its environmental impact during its entire life-cycle, its durability, its economic feasibility, and its cost effectiveness, while ensuring consumer affordability and flexibility of choice. Performance as a cool roof is only one of several factors to consider.

Professional Roofing, October 2008.

[3] Urban, Bryan and Kurt Roth, "Guidelines for Selecting Cool Roofs," U.S. Department of Energy: Building Technologies Program, July, 2010.

[4] "Condensation Problems in Cool Roofs," Bludau, Zirkelbach, Künzel, 2008

[5] Chu, Steven, "White Roofs to Fight Global Warming," *Wall Street Journal*, May 27, 2009

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In addition to the cool roof options described previously, there are many areas of the whole building approach that can be addressed to reduce energy use and accomplish environmental goals.

Insulation

Attic insulation can be used in lieu of, or in addition to, highly reflective roof surfaces. Insulation is often allowed as an alternative to cool roofing. A major advantage of insulation is that it does not require cleaning over its lifetime and works well in both cooling and heating climates, reducing energy usage throughout the year. Additionally, insulation for a steep-slope roof can usually be added without replacing the roof. Proper placement of insulation is an important design consideration.

Ventilation

Ventilation is another approach to address heat transfer from the roof system into the conditioned building space, which can reduce energy usage. Ventilation reduces the temperature of attics and helps to prevent moisture from being trapped in the attic space. A properly designed roof ventilation system keeps air moving from the eaves to the ridge, where warm attic air is exhausted. The movement of air yields improvements in energy consumption by keeping the attic temperature closer to the outside air temperature and prevents moisture from becoming trapped in and prematurely deteriorating the roof deck, the structural wood and even the shingles. In cold climates, proper ventilation can help prevent formation of ice dams.

Sealing and Insulating HVAC Ducts in Attic

Placement of heating and air conditioning ducts in attic spaces is a common construction practice. Significant energy savings can be achieved by ensuring ducts are properly sealed and insulated.

Eliminating Air Leaks into the Attic

Migration of air from the conditioned space of the building into an unconditioned space such as an attic reduces energy efficiency and may increase heating demands. Sealing attic floor penetrations is one simple and straightforward option that can have a significant impact by reducing air transfer between conditioned and unconditioned spaces.

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Radiant Barriers
Research has shown that the use of a radiant barrier can reduce the peak day heat transfer, and depending on the attic configuration, can yield year-round energy savings.[6] The performance of a radiant barrier is affected by its location within the roof system, whether there are ducts in the attic, whether the ducts are sealed and insulated, as well as other factors (e.g., space constraints, storage containers covering the barrier). Use of a radiant barrier may increase the average temperature of the asphalt roof covering, which may have a detrimental effect on durability of the product.[7] However, the amount of temperature difference is typically no larger than temperature differences between light-colored and dark-colored shingles.[8]

Glazing
Glazing elements have a significant impact on building energy efficiency, and proper selection is an important design consideration. Not only must the properties of the glazing elements be considered, but proper installation and integration with other building envelope elements is necessary to assure desired performance is achieved.

BENEFITS OF COOL ROOFS AND THE WHOLE BUILDING APPROACH
When properly utilized in a building's overall design, both cool roofs and the other building enhancements discussed previously can offer benefits for the building owner and the environment.

Improve Energy Efficiency
A reduction in heat transfer from attics into the conditioned space of a building improves energy efficiency in the cooling season, but may have the opposite effect for heating loads. Balancing these competing variables is a complex and critical design consideration that is specific to the building, its geographic location, and the relative cost to heat and cool the building. A combination of options may provide the best design solution. As an example, cool roofing is an excellent choice to reduce solar heat gain, but is an incomplete solution in climates where heating costs predominate. Combining reflective shingles with attic insulation is one approach that may be more appropriate.

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[6] ORNL Radiant Barrier Fact Sheet, 2010
[7] "Understanding Attic Ventilation," *Building Science Digest*, 102.
[8] "Understanding Attic Ventilation," *Building Science Digest*, 102.

Reduce Urban Heat Island Effect

A localized temperature increase in an area with a high concentration of surfaces that absorb and retain solar energy (e.g., roofs, streets, sidewalks) is referred to as the "urban heat island effect." Cool roofs are a viable option to help address this issue. By reflecting a portion of incoming solar energy, cool roofs reduce the heat gain of the roofing surface, resulting in less localized temperature increase. Other approaches to improve energy efficiency (e.g., insulation, ventilation, improved envelope sealing) can help mitigate urban heat islands as well by reducing operating demands on HVAC equipment, which reduces the amount of elevated temperature exhaust released into the local environment.

Reduce Greenhouse Gas Generation

Any building enhancement that reduces building energy use can contribute to a reduction in greenhouse gas generation. However, the magnitude of this benefit depends directly on the fuels used to cool and heat the building. In areas where utilities generate energy primarily from fossil fuels, energy efficiency improvements, including cool roofs, may help reduce greenhouse gas generation. This may not be the case if energy is generated using methods that do not produce greenhouse gases (e.g., wind, solar, hydroelectric).

Offset Carbon Dioxide

Cool roofs have been touted as one mechanism to offset carbon dioxide emissions and potentially delay climate change.[9] Increasing the reflectivity of the built environment is a form of geoengineering intended to reduce the average temperature of the planet, and cool roofs can play a part in this effort. However, application of this concept on a wide scale raises serious questions that are beyond the scope of this paper to address.

Improve Roof Durability

By design, reflective asphalt shingles reflect solar energy away from the roof surface, leading to a reduction in the average surface temperature of the shingles. Since heat is one factor that contributes to shingle aging, the reduction in surface temperature is expected to have a positive—although possibly not easily measurable—impact on asphalt shingle durability.

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[9] "Global Model Confirms: Cool Roofs Can Offset Carbon Dioxide Emissions and Mitigate Global Warming," Lawrence-Berkley National Laboratory News Release, July 19, 2010.

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RESPONSIBILITY AND CONSUMER CHOICE

Cool roofs are required by code or regulation in some jurisdictions. In others, incentive programs are used to drive consumer choice. In many cases, third-party verification of product solar reflectance and thermal emittance is specifically required by these programs. Unfortunately, some jurisdictions (e.g., California) have limited this function to a single organization. Allowing competition in the third-party verification arena will positively affect cost of compliance. ARMA encourages and supports the availability of multiple verification agencies.

Importantly, ARMA believes that the cost of a cool roof must not outweigh its benefits over its lifetime. Building owners and consumers selecting cool roofing options must be confident in the economic value initially and over time.

In some cases, energy efficiency goals are not based on cost effectiveness, but are based on social goals such as reducing greenhouse gas emissions. Society has limited resources to address issues like reducing greenhouse gas emissions, and it makes sense to achieve these alternative goals in the most cost-effective manner.

CONCLUSION

While a roof's primary function is to keep water out of the building, today's environmentally-conscious agencies and consumers have made "cool" an increasingly important consideration in the roof selection process. In a similar fashion, these groups are promoting cool roofs as the best solution to achieve energy efficiency and environmental goals for buildings. ARMA recommends consideration of the potential benefits and limitations of all cool roof options when making roof selection decisions and encourages designers to remember that a combination of strategies may provide the most suitable option. Finally, ARMA believes the best solution will be achieved when cool roofs are recognized as but one option within the "whole building approach" that is available to accomplish energy efficiency and environmental goals.

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The Asphalt Roofing Manufacturers Association (ARMA) is the trade association representing North America's asphalt roofing manufacturing companies and their raw material suppliers. Committed to advances in asphalt roofing, ARMA produces white papers and technical bulletins to educate consumers and industry stakeholders about the benefits of asphalt as the roofing solution.

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