



Roofing Materials for Flat Roofs

A concentrated effort to reduce energy consumption in buildings and their contribution to the “heat island effect” has led to recent advances in the materials and systems for flat roofs (roofs with a slope from ¼ to 3 inches per foot), used primarily in commercial and multi-family construction. Selecting a roofing material that is highly reflective and emissive (cool roof) over one that is not, can reduce cooling loads by 20 percent or more, and help cool urban heat islands.

Broader sustainability issues should also be considered when selecting a roof system. According to the Oak Ridge National Laboratory, sustainable roofing is “a roofing system that addresses the issues of energy efficiency, use of materials with a lower environmental impact and embodied energy, durability with less maintenance, and reduced waste generation throughout the life cycle from design, through construction and re-roofing, to reuse and final disposal”. In the U.S. alone, between 9 and 10 million tons of asphalt roofing waste is sent to landfills annually. A longer-lasting roof reduces the amount of waste sent to the landfill and makes better use of its embodied energy.

This fact sheet discusses the primary factors that should influence your choice of roofing material and presents the pros and cons of the most popular flat roof assemblies.

Building Codes and Regulations

California’s Title 24 Energy Efficiency Standards for Residential and Nonresidential Buildings (2005) establish cool roof performance criteria that apply to low slope (2:12 or less) roofs on nonresidential buildings. A cool roof is defined as one with a solar reflectance¹ of at least 0.70 and an infrared emittance² of at least 0.75. There is also an allowance

¹ Solar Reflectance is a measure of the ability of a surface material to reflect sunlight – including the visible, infrared, and ultraviolet wavelengths – on a scale of 0 to 1. Solar reflectance is also called “albedo.”

² Emittance is the amount of absorbed heat that is radiated from a roof, expressed as a number between zero and one. The higher the value, the better the roof radiates heat.

for a cool roof that has a very high reflectance, but a lower emittance. While cool roofs are not required on nonresidential buildings in California, other parts of the building must be upgraded to achieve the same overall energy consumption of a building with a cool roof. Title 24 also requires cool roof properties to be verified through CRRC ratings, or low default values for reflectance and emittance must be substituted in energy calculations.

Solar Reflectance and Thermal Emittance – The Keys to Energy Savings

The basic concept of a cool roof is to make the roof out of a material that reflects energy and emits heat—not retaining it like the hammer left in the sunshine. When selecting a roof, look for high solar reflectance, endurance of high reflectance over time, and high emittance. Cool roofs, can reduce roof temperature by as much as 100°F during the summer, and thereby reduce the building’s energy requirements for air conditioning. In addition, reflective materials keep the building’s neighborhood cool.

For existing roofs, application of a reflective coating can substantially reduce cooling loads. Coatings can be applied during the construction stage, in retrofit or as a maintenance application. They are suitable for application to any clean, dry and mechanically sound substrate including built-up roofs, modified bitumen, single-ply, or polyurethane foam.

Types of Flat Roof Systems

The most common types of flat roofs, listed in order of increasing durability and cost, are: roll asphalt, single-ply membrane, multiple-ply or built-up, flat-seamed metal and vegetated roofs. They range in cost from as low as \$1.50 per square foot for roll asphalt or single-ply roofing applied over an existing roof to \$24 per square foot for a green roof.

Asphalt roll roofing

Asphalt roll roofing, used since the 1890s, generally consists of one layer of asphalt-saturated organic or fiberglass base felts, applied over roof felt with nails and cold asphalt cement, and usually covered with a granular mineral surface. Seams are typically covered with a roofing compound. Roll asphalt lasts about 10 years.

Single-ply membranes

The most common materials in single-ply roofs are thermoset, thermoplastic, and modified bitumen. They are often less expensive to install, more durable, lighter in weight and more energy efficient than built-up roofs. Single-ply materials can be attached chemically, mechanically, or held in place with ballast, usually gravel or aggregate. Single-ply roofs last between 10 and 20 years depending on the material used and the service conditions.

Since the "single-ply" classification includes both light- and dark-colored materials, products that are highly reflective should be selected for heat island reduction and energy savings purposes. Some of the newest single-ply roof products are made with self-cleaning and mold-resistant polymers to maintain solar reflectance.

Examples of single-ply products include:

- EPDM: a flexible elastomeric single-ply roofing material.
- PVC: a synthetic thermoplastic polymer prepared from vinyl chloride. It is the most expensive of the three, but is well known for long-term performance.
- TPO: a blend of polymers that may or may not contain desirable additives such as flame-retardants or UV absorbers. It can last 30 years and is largely maintenance free.

Built-up roofs

A built-up roof (BUR) consists of the roof deck, vapor retarder, insulation, membrane and surfacing material. The roofing membrane is composed of two components - bitumens and felts. Bitumens provide the waterproofing agents and adhesive properties of the system. The felts strengthen and stabilize the membrane. The roofing membrane is protected from the elements by a surfacing layer, either a cap sheet or gravel embedded in bitumen or a coating material. BUR's have a low albedo – they must be finished with a reflective coating to achieve temperature reduction and realize energy savings.

BUR's require application of a new top layer every ten years. Properly maintained, a BUR can last between 10 and 30 years before it must be completely torn off and a new roof installed. While some components of a BUR system contain recycled materials, a BUR is generally not recyclable.

Metal Roofing

There are two basic classifications of metal roofing; structural and non-structural (also known as architectural). Structural metal roofing attaches directly to purlins or lathe boards and does not require any sort of solid support beneath it. Non-structural metal roofing requires a solid substrate beneath it, typically plywood, oriented strand board, or a metal roof deck. Metal roof systems typically vary from 40 to 150 pounds per 100 square feet, making them among the lowest weight roofing products available. Low weight places fewer demands on a building's structure making metal roofing a great choice for retrofit projects. The light weight is also a benefit in locations prone to seismic activity.

Low slope structural metal roofing consists of interlocking panels, commonly called standing seam roofing, that run vertically on the roof surface. These products can have a painted, mill-finish, or clear acrylic finish. To ensure water-tightness on roofs of less than 3:12 pitch, some products require machine seaming during installation. Galvanized iron requires regular painting to avoid corrosion.

Most metal roofing products carry manufacturers' warranties lasting from 20 to 50 years. However, most products have been designed so that they can be refurbished on site for additional life once their original finish reaches its useful life. Many of the metals used in roofing have recycled content varying from 25% to 95%, often with much of that recycled content being in the post-consumer category. Metal roofing materials are 100% recyclable in the event they are ever removed. The long life and low maintenance of metal roofing, combined with the savings from energy efficiency, give it a very attractive life-cycle cost.

Cool Roof Coatings

Cool roof coatings are usually white liquids applied over an existing roof structure. They can be applied over a traditional roof to achieve energy savings, an extended life span, and protection from weathering and ultraviolet (UV) radiation. Since these coatings reduce the temperature of the substrate, they can extend the life of the material due to reduced thermal shock (large and rapid changes in temperature) and reduced expansion and contraction of the roof structure. The new surface can last 10, 20 years, or longer. They cost between \$0.75 and \$1.50 per square foot for materials and labor.

Roof coatings are able to retain solar reflectance over time. The Lawrence Berkeley National Laboratory

found that the reflectance of cool coatings decreases by only about 20% over the product's lifespan, and that most of this decrease occurs in the first year after application.

Vegetated (Green) Roofs

Becoming very popular in Europe these roofs are green – in more ways than one. Vegetated roofs are comprised of a membrane – either thermoset or thermoplastic - topped with soil and vegetative cover and are well suited for flat roof applications. Not only do they reduce the building's energy consumption and the local heat island effect, they also absorb rainfall, thereby reducing urban storm water runoff. Since the soil protects the membrane from UV radiation, it should last decades longer than a membrane exposed to the elements. However, it is critical that the membrane selected be one that is resistant to root intrusion.

It is important that the plants selected for a green roof be able to withstand full sun exposure and tolerant of temperature extremes. Plant size will depend on the depth of the roof overburden (growing medium) and local climate. Low growing plants such as grasses, sedums, and other cactus-like plants are used where the depth is only a few inches (extensive green roof). Where the medium depth is several feet (intensive green roof), shrubs and even small trees can be used. The supporting structure should be engineered and constructed to be able to support the weight of the vegetation and soil, especially when it is saturated from rainfall.

Green roofs offer multiple economic and environmental benefits including:

- Protection of roof membrane resulting in a longer material lifespan (it is estimated that green roofs will last up to twice as long as conventional roofs), resulting in decreased maintenance and savings in replacement costs.
- Savings on energy heating and cooling costs.
- Reduction of the 'Urban Heat Island Effect' (the difference in temperature between a city and the surrounding countryside). This reduction will also reduce the distribution of dust and particulate matter throughout the city and the production of smog.
- Potential to reduce the size of HVAC equipment (capital and operational savings).
- Potential to reduce the amount of insulation used.
- Potential to reduce or eliminate roof drains.

- Potential to meet regulatory requirements for storm water management.
- Noise reduction: soil, plants and the trapped layer of air can be used to insulate for sound. Sound waves produced by machinery, traffic or airplanes can be absorbed, reflected or deflected. A green roof can reduce sound by 40 decibels or more.
- Provision of amenity space for meetings and recreational activities
- Aesthetic appeal, increasing the value of the property and the marketability of the building as a whole, particularly for accessible green roofs.
- Potential for local, regional, and national market exposure, depending on the uniqueness of the project and potential to reduce community resistance to new developments.

The cost of a green roof varies considerably depending on the type and factors such as the depth of growing medium, selected plants, size of installation, use of irrigation, and whether they are to be accessible or inaccessible - intensive, semi-extensive or extensive. Intensive green roofs typically require greater investment but confer the benefits of accessibility. An installed extensive green roof with root repellent/waterproof membranes may be installed for \$9-\$24 per square foot. While green roofs typically require a greater initial investment, it is important to keep in mind that they can extend the life of the roof membrane and substantially reduce the heating and cooling costs of your building.

Cost Comparisons

The up-front price of a roof product depends on the initial cost of the roof materials and the additional cost of installation. Reflective roofs are usually cost-competitive with traditional roofs at the time of purchase. Metal and green roofs have a considerably higher first cost. When the life-cycle costs of cool and traditional roofs are compared, however, cool roofs are less expensive. This is because, once installed, electricity demand is reduced and summertime savings on energy bills begin to add up. In fact, experience has shown that, over time, cool roofs pay for themselves through energy savings, reduced maintenance expenses and a significantly longer life span.

Cool roofs can be installed on both new buildings and older structures due for re-roofing. Because most roofs require regular maintenance, as well as periodic re-roofing or recoating, opportunities to switch to

cool materials and improve roof reflectance are presented regularly.

For more information

- List of Energy Star Roof Products; US Environmental Protection Agency:
http://www.energystar.gov/index.cfm?c=roof_products.pr_roof_products
- Lawrence Berkley National Laboratory – Cool Roofing Materials Database
<http://eande.lbl.gov/CoolRoof/>
- The Cool Roof Rating Council (CRRC) is an independent organization that has established a system for providing building professionals with accurate radiative property data on roof surfaces that may improve the energy efficiency of buildings while positively impacting our environment. www.coolroofs.org
- Product Listing; Cool Roof Rating Council
www.coolroofs.org/documents/December2005ProductDirectory121605.pdf
- Green Roofs for Healthy Cities are dedicated to developing the market for green roof infrastructure products and services in North America. www.gree_nroofs.net
- For more information about the Coalition, visit our website at www.greenaffordablehousing.org or call Bruce Mast at 510-271-4785.

Disclaimer

Development of this fact sheet was funded by California ratepayers under the auspices of the California Public Utilities Commission (Commission). It does not necessarily represent the view of the Commission, its employees, or the State of California. The Green Affordable Housing Coalition, the Commission, the State of California, its employees, contractors, and subcontractors make no warranty, express or implied, and assume no legal liability for the information in this report, nor does any party represent that the use of this information will not infringe upon privately owned rights. This report has not been approved or disapproved by the Commission, nor has the Commission passed upon the accuracy or adequacy of the information in this report. Contents are provided for general education and informational purposes only. The actual suitability and applicability of this information for a given use depends upon a host of project-specific considerations. The Green Affordable Housing Coalition strongly encourages the reader to consult with a construction professional and/or product supplier before applying any of this information to a specific use or purpose.