Roofmeadow
Green roofs. For good.

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ROLE OF GREEN ROOFS IN MANAGING THERMAL ENERGY

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From a heat flow perspective, the performance of green roofs as 'insulators' depends greatly on a number of variables, including the moisture content and temperature regime. In fact, the physical processes producing the benefit are many and varied.

As the summary below indicates, true thermal insulation is the least important of these. The benefits associated with shading, reduction in wind-related losses, and heat absorption are much more important. For this reason, it is impossible to regard green roofs as equivalent to conventional insulation materials. It is much more useful to think of green roofs as systems that greatly improve the function of conventional insulation materials.

Shading effect

This benefit applies primarily to the warm season, when the concern is too cool the underlying building. The 'shading effect' of the vegetation can be dramatic. The foliage absorbs radiant energy and prevents it from reaching the surface of the growth media. The benefit is even greater than that associated with 100 percent shading by screens or trees, since the foliage prevents air circulation below the foliage. Therefore, heat transfer caused by hot wind blowing across the roof surface is minimized.

Retarding heat transfer by advection

A very important function of the vegetation layer is to create a quiescent layer of air immediately above the roof surface. Without a green roof, wind (hot or cold)blows across the roof surface to either heat or chill it through the process of advection. The higher the air velocity the greater the thermal transfer. The concept is familiar to us as 'wind chill.' Buildings experience wind chill as well.

Thermal mass effect

This is the most important property of green roofs. Especially when moist, green roofs can absorb and store large amounts of heat. The effect is to create a 'buffer' against the daily fluctuation in temperature. Even a 3-inch green roof will drastically reduce the variation in temperature of the roof surface. Of course, the rate of heat transfer is greatest when the temperature differential is large between the inside and outside temperature. With a green roof in place, the extremes of temperature are eliminated. The result is that 1) heating or cooling equipment does not have to respond to the 'peak' loads at mid-day or mid-night, and 2) the overall heat transferred through the roof is reduced. The use of thermal mass in building systems to improve efficiency is becoming increasingly prevalent.

Note that conventional insulation, while optimized for insulation value, has virtually no heat capacity and cannot function as a heat sink. This is an instance in which a green roof can work in combination with conventional insulation to provide a benefit greater than either used separately. As a generalization, the temperature at the base of a vegetative cover will closely follow the monthly seasonal averages for an area.

Evapotranspiration

This process is only important in the summer. The moisture trapped in the root zone of plants and in the foliage layer as droplets evaporates. This process will continue as long as there is sufficient moisture in the growth media. The effect is to actively cool the air immediately over the roof surface. Depending on conditions, this effect can be large.

Retarding heat radiation

Another benefit of foliage is that it absorbs radiant energy, utilizing it to fuel photosynthetic biological processes. This is unlike white or silvered roof surfaces that reflect the radiation back into space (or the windows of adjacent buildings). Therefore, green roofs are more effective than reflective roofs in combating problems related to the 'urban heat island effect.'

Green roofs as simple insulators

When dry, a green roof will acts like a simple insulation layer. This is true even when the layer is frozen, since the air trapped in the frozen layer continues to provide insulation. The 'R' value of this layer will depend upon the formulation of the growth media. Fine-grained media, which also have a high porosity, will provide the best insulation. It is reasonable to expect dry green roofs to offer an effective 'R' value of anywhere between 2 and 5 per inch, depending on design. However, when the green roof is moist (which is most of the time in temperate climates) the insulating value is reduced.

Due to the complexity and interplay of all of all these factors, most data pertaining to the thermal properties of green roofs is only useful in leading to generalizations about potential benefits. Predictions of thermal energy management benefits are possible with the assistance of building envelope analysis techniques that can integrate the effects of insulation, shading, and thermal mass. To arrange for this analytical service, please contact Charlie Miller cmiller@roofmeadow.com or 215-247-8784.