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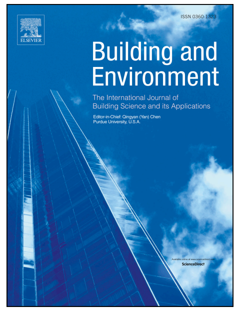

Heat flux and seasonal thermal performance of an extensive green roof

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Heat flux and seasonal thermal performance of an extensive green roof

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Abstract: Green roofs influence the overall energy balance of buildings. In this study, the thermal properties of a green roof are determined using field data gathered from an extensive 0.56 ha green roof in Syracuse, NY. Sensors installed at five stations across the roof measure temperature at four depths within the roof layers. Data have been gathered from September 2013 to September 2015. Heat fluxes range from -5.76 Wm^{-2} to 9.46 Wm^{-2}. Negative (downward) heat flux is found during summer and early fall, and positive (upward) heat flux dominates during the heating season. Solar radiation can heat the upper layers of the roof significantly above ambient air temperatures during the summer. Accumulated snow acts as an insulator during the winter months. Thermal resistance, R, is determined during a two-week period with significant snow accumulation, during which time heat flow through the roof reached a quasi-steady state. Thermal resistance for the overall roof is found to average 3.1 m^2KW^{-1}. The largest individual thermal resistance is from the extruded polystyrene insulation layer (R=2.6 m^2KW^{-1}). Overall, the green roof dampens the extreme responses often observed on urban roofs. Vegetation and substrate layers may be used in addition to insulation, but are not recommended in lieu of insulation for a Central New York climate.

Keywords: green roof; building energy; building insulation; r-value; heat flux

1. Introduction

Urbanization throughout the past century has led to the increasing destruction of the natural environment and a greater fraction of impermeable surface cover. With these changes, many ecosystem services are destroyed and natural cycles are altered. Green roofs, or vegetated roofs, are often cited for their ability to provide quasi-natural surfaces. Such roofs can help regulate thermal processes, leading to reductions in building cooling and heating loads and decreases in the urban heat island (Dunnett and Kingsbury 2004; Takebayashi and Moriyama, 2007). Increased availability of water, stored in the soil and drainage layers, enhances evapotranspiration, which can result in passive cooling (Sailor et al. 2012; Tsang and Jim 2011). One study of a roof equipped with an irrigation system in a Mediterranean climate found that the roof membrane temperature never exceeded that of the ambient air during the warm season (Theodosiou et al. 2014). Most competitive roofing technologies, i.e., white roofs, are successful when properly maintained but cannot cool to below ambient temperatures, as demonstrated by some green roofs (Zinzi and Fasano 2009). Researchers in New York City found that on average a green roof daily peak membrane temperature in summer was 33°C cooler than a black roof peak membrane temperature (Gaffin et al. 2010). In an earlier study, the same researchers found the albedo of a green roof to be 0.2, while that of a maintained white roof was 0.7. They found that the albedo alone did not explain the thermal behavior of the roof, citing additional cooling on the green roof from latent heat loss (Gaffin et al. 2005). In Toronto, researchers found that average daily heat flow through a green roof was reduced 70-90% in the summer and 10-30% in the winter relative to a traditional roof. Peak membrane temperatures were reduced by the green roof and were delayed by 5 hours relative to a traditional roof (Liu and Minor 2005).

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