DESIGN OF A GREEN ROOF WITH INTEGRATED MONITORING EQUIPMENT

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Abstract

In 2005, a green roof will be constructed on the south wing of Hamerschlag Hall at Carnegie Mellon University in Pittsburgh, PA. The new green roof and an existing roof on an adjacent building will be instrumented to allow a comprehensive evaluation of green roof performance with respect to stormwater flow and quality, energy use within the building, and the urban heat island effect. Data will be collected for at least one year. The results are expected to demonstrate the feasibility of the monitoring scheme for quantifying the benefits of a green roof.

Introduction

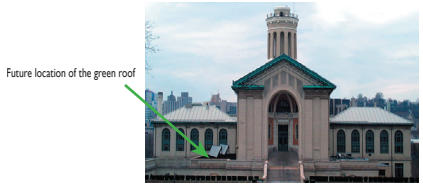
Relatively little measured data are available to quantify the benefits of green roof systems in the U.S. Since green roofs are dynamic ecosystems, performance can be expected to vary by season and by climate. By implementing comprehensive monitoring on a new green roof on Hamerschlag Hall, we intend to produce a complete evaluation of green roof performance for one particular climate condition.

Performance will be evaluated in terms of:

- ***Stormwater management***
- ***Stormwater runoff quality***
- ***Building energy use***
- ***Urban heat island effect***

The green roof will be constructed on on top of the existing decking on a flat 370 m^2 roof on the south wing of Hamerschlag Hall (Figures 1 and 2).

Figure 1. Hamerschlag Hall at Carnegie Mellon University



Experimental Approach

Measurements will be performed on approximately 3/4 of the green roof. An equal size roof area on an adjacent building will be used as a control.

- ***Stormwater management***
  - Variables: runoff flow rate, total volume
  - Measured by: instrumented flumes near two drains on the green roof and one drain on the control roof (Figure 3)
- ***Stormwater runoff quality***
  - Variables: dissolved and suspended chemical species
  - Measured by: analysis of runoff samples from selected storms
- ***Building energy use impacts***
  - Variable: heat flow through the roof system
  - Measured by: bi-directional heat flux sensors beneath the membranes on both roofs
- ***Urban heat island effect impacts:***
  - Variables: roof surface temperature, air temperature directly above the roof surface
  - Measured by: infrared thermocouples for surface temperature, shaded temperature sensors for air temperature
- ***Additional analyses***
  - Detailed temperature profile of both roofs, from integral temperature sensors in the green roof (Figure 4) and the control roof
  - Effects of soil saturation on thermal performance, from soil moisture sensors in the green roof growing medium and heat flux measurements

Figure 2. Layers of the Hamerschlag Hall Green Roof

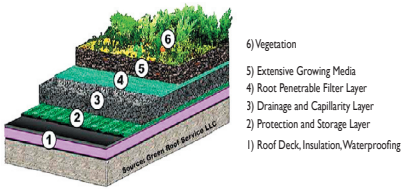


Figure 3. Detail of flume for runoff measurements

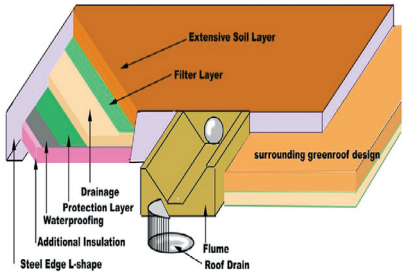
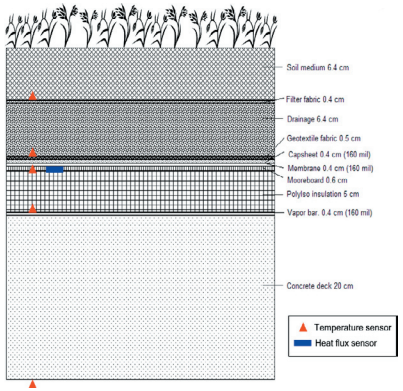


Figure 4. Detail of integral temperature and heat flux sensors



Expected Results & Discussion

The data collected from the Hamerschlag Hall green roof will be among the most comprehensive in the U.S. to date. The methodology and results should prove useful to other researchers who wish to examine green roofs. Based on the findings of previous green roof research, we expect the following results:

- ***The green roof will reduce the total amount of stormwater runoff by roughly half over the annual cycle***. Variations by season are expected.
- ***Stormwater runoff from the green roof is expected to contain higher levels of nitrogen, phosphorus, and other elements***, at least initially, due to leaching of these materials from the green roof growing medium
- ***The green roof is expected to significantly reduce the amount of summer heat gain through the roof*** by shading, insulation and evaporative cooling. In other seasons, performance will depend upon climate-driven factors such as soil saturation and the freeze-thaw cycle of the growing medium.
- ***The surface temperature of the green roof is expected to be significantly lower than that of the control roof,*** due to shading and evapotranspiration. It is unclear to what extent this will translate into a moderation of air temperature above the roof.

Figure 5. Hamerschlag Hall green roof plan