Columbia University Greens Up with Green Roofs

The seven green roofs atop buildings in and around Columbia University's Morningside Heights campus in Northern Manhattan total 18,180 square feet. New York City's annual rainfall averages 50 inches, and Columbia's green roofs can prevent as much as 420,000 gallons of stormwater runoff every year. With New York's stormwater management challenges, the reduction in the total amount and peak intensity of runoff from the University's green roofs contributes to an important environmental benefit for the city: reduced pollution and improved water quality.

New York, like many older cities in America, still maintains a combined sewer system for stormwater and wastewater. The system often reaches its capacity, especially during heavy rains. In less than half an hour of rainfall, New York's sewers can start to back up and flood, sending a polluted mix of stormwater and sewage spilling into the city's waterways, including the Hudson River near the Morningside campus. Thus, Columbia University is helping to demonstrate how green roofs can support stormwater mitigation in New York.

Columbia University's highly urbanized space with the Hudson River in the background.

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Stormwater management and sanitary sewer system overflows are significant environmental issues for many other large municipalities across the United States. Columbia's experience in New York, therefore, is instructive for government officials, facility owners, landscape architects, engineers, consultants and contractors who are contending with these problems in other locales.

The Big Picture

Columbia has three campuses in the New York City area. The main Morningside Heights campus, which encompasses approximately 32 acres, is located in a highly urbanized area on the Upper West Side of Manhattan with its main entrance on

Pre-vegetated green roof mats roll out like sod.

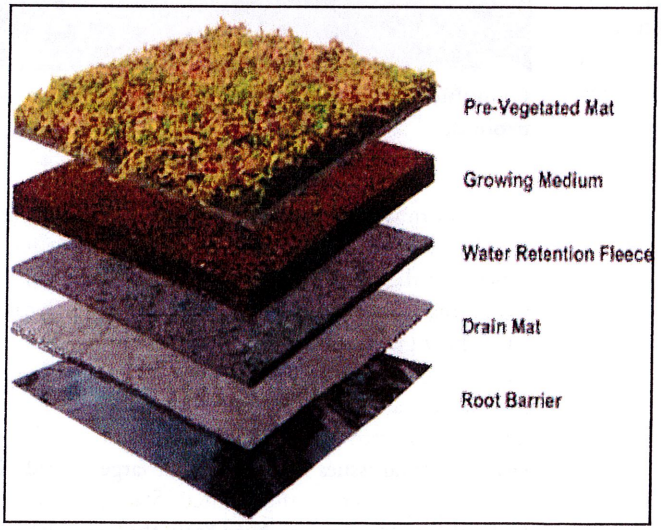
West 116th Street and Broadway. Riverside Park and the Hudson River are just a few blocks to the west. University Facilities at Columbia is responsible for supporting the core educational and research missions of the University by maintaining a safe, beautiful and functional campus environment. At Columbia, green roofs (and in particular the impact of green roofs on controlling the volume and velocity of stormwater) are one element in the University's wide-ranging sustainability programs.

Facilities spearhead comprehensive efforts to make Columbia a model of environmental stewardship. Joseph A. Lenuso, executive vice president of University Facilities at Columbia, has explained that the University's commitment to sustainability guides a range of initiatives to manage the life cycles of both new and older buildings, reduce waste, increase recycling, boost energy efficiency, and conserve resources. LEED® (Leadership in Energy and Environmental Design) certification for new and renovated buildings, using hybrids for official campus vehicles, promoting bike-friendly infrastructure and historic preservation – as well as green roofs – are among the initiatives Facilities undertakes to make the University environment greener.

Moreover, along with other universities in New York City, Columbia has taken on Mayor Michael Bloomberg's challenge to join in pursuing the city's ambitious goal of reducing greenhouse gases by 30 percent by 2017. Columbia has embraced the challenge and has pledged to decrease the carbon footprint of the Morningside campus by 30 percent. Green roofs are part of the University's strategy to meet this commitment.

Green Roof Initiatives

Columbia first began the process of considering green roof applications as an element of its sustainability programs in 2005. The University issued initial project design specifications for bid in 2006.



The Xero Flor Green Roof System.

Three basic benefits were particularly significant in Columbia's decision to experiment with the installation of green roofs:

Improved Thermal Performance – On hot, sunny days, the surface of a conventional rooftop heats up and can exceed ambient air temperatures by 80°F to 90°F. Green roofs shade and insulate the rooftop and maintain roof temperatures in line with air temperatures. Roof surfaces below a green roof can actually be cooler than the air above. By reducing the effects of the sun's energy on rooftop temperatures, green roofs enhance buildings' thermal performance. Green roofs thereby reduce peak energy demand, above all for air conditioning. That helps conserve energy, thereby controlling facilities' utility costs and lessening their carbon footprints.

Urban Heat Island Effect Moderation – Solar energy absorbed into buildings and paved surfaces is transformed into heat. Temperatures in highly developed urban centers like New York City can routinely exceed temperatures in nearby suburban and rural areas by as much as 13°F - 16°F. In the process of photosynthesis, plants release oxygen and evaporate water. As a result, through evapotranspiration, green roofs function like a natural evaporative cooling system and lower temperatures not only up on the rooftop but down at street level as well. Reducing the urban heat island effect is critical for improving the urban environment and decreasing the carbon footprint of cities.

Carbon Sequestration – Green roofs also play a direct role in reducing greenhouse gases in the atmosphere. During photosynthesis, like all plants, green roof plants take in and store carbon dioxide and other forms of carbon from the air. Every 1,000 square feet of an extensive green roof can sequester about 250 total pounds of carbon dioxide. In addition, green roofs also filter particulates and air pollutants and improve urban air quality.

In evaluating and selecting a green roof system, Columbia wanted a lightweight system, especially given the limits of some of its older

buildings' structural roof loads. That made a pre-vegetated mat system a logical choice. According to Patricia J. Culligan, Ph.D., professor of civil engineering and engineering mechanics at Columbia and the vice dean of academic affairs at the School of Engineering and Applied Science, the advantages of a pre-vegetated mat system over other extensive green roof alternatives (such as modular tray systems or build-in-place green roofs) include light weight, relative lower cost, and ease of installation.

The University also prioritized proven performance. After considerable research and due diligence, Columbia chose the Xero Flor Green Roof System from Xero Flor America (XFA), Durham, N.C. This system's pre-vegetated mats utilize sophisticated German technology. It has been refined over more than 40 years of continuous research and development and proven in tens of thousands of installations that cover hundreds of millions of square feet worldwide. The most notable Xero Flor project in the U.S. is the green roof installed in 2003 on Ford Motor Company's River Rouge Plant in Dearborn, Mich. At 454,000 square feet, it is the largest green roof on a single, freestanding building in the country. The new green roof on the Javits Convention Center in New York City also uses the system. When completed in November 2013, it will total 292,000 square feet and will be second in size to the Ford installation.

Columbia's seven green roofs reduce stormwater runoff.

The system's pre-vegetated green roof mats feature Sedum and moss vegetation grown in an engineered, lightweight aggregate growing medium on a permanent flexible textile carrier. With this patented textile-based design, the plant material and growing medium are woven together into the underlying textile material. As a result, the mats can be rolled up, transported by truck to the project site, and rolled out like sod on rooftops. They are installed atop three system components: a retention fleece, a drainage mat and a root barrier. Placed right over a roof's waterproof membrane, the root barrier is a durable plastic

layer that prevents root encroachment and protects the membrane. The drainage mat, a geotextile fabric, which goes on top of the root barrier, is designed to allow excess water below the green roof vegetation to flow to roof drains. The retention fleece is a layer of non-woven fabric placed directly under the pre-vegetated mats themselves. It facilitates distribution and storage of water within the root zone of the plants.

The vegetative mats for the Columbia green roofs were propagated with the Xero Flor Northeastern U.S. Plant Mix, which includes a minimum of a dozen different varieties of Sedum selected for regional suitability. Such plant variety promotes diversity, supports a dynamic plant community on the rooftop, and results in a green roof that more stably adapts to the particular environmental conditions of each installation. The mats are grown in production fields on independent, locally owned farms located in the climate zone where they will be installed. That enables the plants to adapt to specific regional climates.

Columbia's seven green roofs were installed in 2007 and 2008. They are primarily on residential buildings and student dormitories and range in size from 650 square feet to 5,400 square feet.

Green Roof Experience

A team at Columbia University (including Stuart A. Gaffin, Ph.D., research scientist in the University's Center for Climate Systems Research and adjunct associate professor in ecology, evolution and environmental biology) is engaged in studying the performance of a set of green roofs on buildings located around New York City. The National Science Foundation's Geotechnical Engineering Program has providing partial support for their work. One of the green roofs the team has instrumented for their investigations is the 3,180-square-foot green roof on the rooftop of a seven-story residential building owned by Columbia and located at 423 West 118th Street.

The team analyzed data for fifteen rainfall events recorded between August and December 2009. The volume of runoff from the Columbia roof was always observed to be at least 50 percent less than the total amount of precipitation during each event, even for the more severe rainstorms. In addition, for all events examined, the peak flow of stormwater from the green roof was 90 percent lower than the peak flow intensity of the storms.

The team has determined that daytime high temperatures on the New York City green roofs routinely stay significantly cooler than standard black roof surfaces. And, as reported in the New York Times, the green roofs have the effect of reducing the rate of heat gain through buildings' roofs in summer by approximately 80 percent and cut the rate of heat loss through the roofs in winter by about one-third. In 2010, the Columbia researchers estimated that a green roof of about 10,750 square feet could save approximately $225 a year in cooling costs and from $330 to $350 annually in heating costs in New York.

Lessons Learned

Based on the University's experience to date, Columbia anticipates greening up more roofs in the years ahead. Applications of green roof systems at grade level are another possibility under consideration.

Finally, some basic lessons about green roofs learned at Columbia center on three issues:

Preventive Roof Inspection – Any overburden, whether it is ballast stone, pavers or a green roof, complicates visual inspection of a roof's waterproof membrane. Maintenance staff may need to temporarily remove these layers for roof inspection, repairs or modifications. Thus, when evaluating green roof alternatives, it is important to compare the requirements and costs involved in temporary removal.

Green roofs can be installed over an electronic leak detection system, which allows non-invasive leak testing or localization. This can be an effective approach for membrane performance maintenance. Such systems can be considered when planning for a new green roof.

Green Roof Maintenance – Basic maintenance for the Columbia green roofs has included twice per year weeding plus annual application of an organic, controlled-release fertilizer. It generally requires about 30-60 minutes per roof visit. Columbia's facility managers have concluded that supplemental monthly maintenance during the growing season is advisable. The process includes visual inspection of the rooftop and handpicking any weeds so they cannot get established. It is also prudent to inspect roof drains as part of routine maintenance and to pick up any trash that may have blown up onto a roof.

Green Roof Irrigation – Regional climates impose different requirements for watering green roofs. Some in the green roof industry suggest that watering to augment rainfall is rarely required in temperate climates. Columbia has found that additional watering is necessary for its green roofs. Just an inch of additional water per month during the hottest days of the growing season helps the plants stay hydrated and healthy. A supplemental irrigation system can be a good idea, especially for larger green roofs or in installations where rooftop access is limited or difficult so that watering with a hose by hand or with a sprinkler is cumbersome.

Scientists at the National Oceanic and Atmospheric Administration have reported that in 2012 temperatures in the contiguous United States were the hottest in more than a hundred years of recordkeeping. Climate change continues to make summers hotter. Higher summer temperatures make green roofs even more important for the urban environment and make supplemental irrigation in historically temperate regions even more vital for green roof success and sustainability. **L&W**

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