A New York Story: Case Studies in Green Roof Retrofits

Scott Melching, AIA, LEED BD+C GRP, *FXFOWLE*
Jonathan Resnick, President, *Jack Resnick & Sons*
Teresa Carleo, Founder and President, *Plant Fantasies*

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Introduction

As a major metropolis with a growing population, New York City's land values continue to rise while the number of vacant parcels are shrinking. Opportunities for new exterior spaces are scarce on the ground plane. With such an extensive urban fabric of building stock, New York City building owners are constantly seeking ways to harness the potential of their rooftops. There are over 2 million existing buildings in New York City comprising 55% of the city's land area. Rooftops account for almost 20% of the city's area, 20-30 times the size of Central Park.

The benefits of retrofitting existing buildings with green roofs are vast – from stormwater capture and urban heat island reduction to increased habitat and species diversity. Given that every existing structure is unique, green roof retrofit efforts require an intelligent strategy based on the distinct programmatic, technical and financial constraints of each project. This article will highlight some of the opportunities and challenges encountered on two distinct Manhattan projects.

250 Hudson is a 16-story office building owned and managed by Jack Resnick & Sons in Manhattan just west of SoHo. The building benefits from panoramic views of the city in four directions – lower Manhattan to the South, the Hudson River to the West, SoHo to the East and the Empire State Building to the North. As part of the building-wide renovation, FXFOWLE Architects along with Plant Fantasies designed an 8,000 SF green roof amenity space available to all building tenants.

Symphony House, also owned and managed by Jack Resnick & Sons, is a 43-story mixed-use office and luxury residential tower in Midtown West. The building's distinct shape includes a set-back at the ninth floor between the podium office component and the residential high rise. FXFOWLE and Plant Fantasies renovated the former quarter-mile jogging track into 12,000 SF of semi-intensive green roof amenity space available to all residential tenants.

Motivations

In 2007, Jack Resnick & Sons reached out to FXFOWLE to create a green roof as part of the redevelopment of 250 Hudson. An owner of multiple properties in the City, Resnick's goal in the commercial property redevelopment was to set the building apart from its neighbors in Hudson Square. A complete renovation began in 2008 that would reposition the office building in a way that would attract new tenants

[1] City of New York, 2008. Greener, Greater Buildings, PlaNYC.

"Because tenants were to have access to 250 Hudson's green roof, it was necessary to satisfy building-code egress and ADA requirements. Thus, the amount of accessible/usable space was dictated by the available means and methods of exiting. Once this was resolved, we had the freedom to use larger plantings and add other features that greatly enhance the quality of the experience."

– Bruce Fowle, FAIA Founding Principal FXFOWLE

and increase rental revenues. The successful partnership formed between Jack Resnick & Sons, FXFOWLE Architects and Plant Fantasies at 250 Hudson led to the development of the next green roof retrofit at Symphony House. Each project presented distinct challenges based on their respective existing conditions. As such, FXFOWLE developed a systematic methodology to carefully analyze the idiosyncrasies of each building. Outlined below are the components of the feasibility study that proved invaluable in the customization and overall success of both green roof retrofits.

Considerations

Converting unused existing roof space into a dynamic design feature for tenant enjoyment can be challenging. Careful examination and analysis of the existing conditions from the onset helped to overcome many of the largest hurdles to the projects. Below is a list of the critical structural and building code issues that require investigation to undertake a rooftop renovation:

Available Roof Space

Available roof area is the first consideration when evaluating the possibility of installing a green roof. To maximize usable interior (rentable) space most Manhattan rooftops are densely packed with large chillers and air handlers. Advancements in the design of mechanical systems have greatly reduced the size of rooftop mechanical equipment. Oftentimes, by conducting a study of the existing conditions an engineer can determine if the existing mechanical units can be eliminated, reduced in size, or relocated. Chillers or condensers can often be stacked to conserve space.

At 250 Hudson, new rooftop chillers were added as part of the building renovation. Working closely with the mechanical engineer to consolidate and stack rooftop equipment above the penthouse office space preserved 8,000 square feet of roof area for a green roof amenity. The 9th floor roof at Symphony House was already free of mechanical equipment; therefore the green roof installation was unencumbered.

Structural Roof Capacity

Before plants, roof pavers and occupants can be incorporated onto a roof, it is critical to determine if the structural capacity of the existing roof construction is adequate to support additional live and dead loads required for assembly occupancy. Typically, a roof structure is designed to meet building code minimum load (40 lbs/sf snow load) in New York as opposed to the 100lbs/sf live load required for assembly spaces.

Calculating an existing roof's capacity is not always straightforward. The simplest method is to review the building's certificate of occupancy, which states the floor loads and use for each level. The next option is to contact the building's original structural engineer or architect - depending upon the building's age, this oftentimes proves difficult. The most complex and last resort for structural identification

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Structural probe at 250 Hudson

is undertaking a probe of the roof's structure. This involves cutting into the roof assembly from above to evaluate the structure of the roof. By measuring the thickness of the beams, concrete slab and roofing material, a structural engineer can calculate the available capacity. To complete the calculations, the interior column spacing and floor to floor heights will need to be considered.

After probing the roof at 250 Hudson, the structural capacity was deemed insufficient to support a green roof. In order to make the green roof vision a reality, a new structural concrete slab was installed above the existing concrete roof to provide the required support. Adding the new structural slab was costly and time consuming. By contrast, at Symphony House, the structural engineer was able to confirm that the required loads were available by reviewing as-built drawings.

Accessibility and Egress

Accessible assembly roof spaces require three elements – a minimum of two egress stairs, an elevator that provides direct access to the exterior space, and a connection between the interior and exterior space that conforms to ADA requirements. It is rare to find all three requirements already in place. When visiting a potential roof space it is critical to carefully review how the roof is accessed. If steps are required to access a higher exterior roof level, it will be more challenging to provide access than if the roof is lower than the interior space, where it is possible to utilize adjustable paver pedestals to align the interior and exterior finish floors in lieu of stairs. The roof at 250 Hudson was higher than the interior floor level. To provide an accessible route, two steps and an extra accessible ramp were added as part of the green roof design. This was only possible because

the new structural concrete slab was engineered to accommodate a depression aligning with the interior floor. As part of the building renovation new elevators were added to access the roof level.

The existing conditions at Symphony House were the converse of those found at 250 Hudson. The ninth floor already had full access to the residential elevators and the existing roof was lower than the interior finish floor. Concrete pavers were installed on adjustable pedestals in order to align the interior and exterior floor evels, creating a seamless transition between interior and exterior.

Waterproofing Membrane and Warranty

It is always important to select waterproofing membranes and green roof systems that are compatible and won't damage one another. Plant roots can deteriorate many bituminous membranes while TPO and PVC are not as susceptible to deterioration. If a bituminous membrane is selected, manufacturers require a root barrier be placed between the membrane and the plants.

At both 250 Hudson and Symphony House, modified bituminous membranes were installed with root barriers above them. Due to the increased height of the roof at 250 Hudson, new counter flashing was installed along the parapet wall. At Symphony House, the existing through-wall flashing was reused and only the counter flashing required replacement.

A multiple source warranty indicates the roofing assembly is warrantied separately from the green roof assembly. The advantage of this system is freedom to select diverse plants and vary the depth of the growing medium. The disadvantage of this system becomes evident when a leak occurs – initiating a two-step process. First, the landscaper must remove the green roof to provide the roofer access to the membrane. Once the leak is fixed, the landscaper is responsible for replacing the green roof.

250 Hudson and Symphony House were both multiple source warranties. Installation of built-up green roof systems at both projects provided maximum flexibility of plant selection.

Edge of Roof Condition

Most existing inaccessible or mechanical roofs do not have parapets. Accessible roof amenity spaces require a 42" tall guardrail at the perimeter of all gathering spaces. The construction of a green roof typically increases the finished elevation of the roof by 8"-24" which alone renders most existing parapets inadequate by code.

Adding a new guardrail can be challenging depending on the condition of the existing parapet. Parapets are unique building elements that are exposed to the weather on three sides – often causing the parapet wall to deteriorate more rapidly than the rest of the building exterior.

At 250 Hudson, the finished floor was raised 18" to accommodate the new structural concrete slab, building insulation, drainage mat, paver pedestals and roof pavers. This added thickness reduced the existing parapet height from 38" to 20" after construction. New guardrails were designed throughout to meet the 42" code requirement, but the design team had to first determine how to best attach them to the existing parapet.

The structural engineer determined the parapet was capable of supporting a new guardrail if anchored to the inside face at 250 Hudson. To limit the number of penetrations through the waterproofing membrane, it is preferable to anchor railings to the parapet above the counter flashing rather than to the structural slab below.

Parapet railings can experience high wind loads. At 250 Hudson, instead of a solid glass wind screen to block the wind, the design team created frames with a stainless steel mesh infill that allowed the wind to pass through, adding only minimal loads to the connection at the parapet. At Symphony House, the existing brick parapet was 42" tall and in excellent condition. Having a code-compliant railing already in place significantly shortened the length of the project's construction schedule.

Access to Sunlight

A critical part of the analysis process is studying the roof's access to direct sunlight. To do this, the design team used a 3D modeling software called Ecotect. Ecotect is an analytical tool that utilizes the building's geometry, neighboring structures and geographic location to calculate the amount of direct sunlight the roof receives relative to the sun's path throughout the year. By understanding the day lighting levels, plants can be appropriately selected to match the conditions: full sun, partial sun or shade tolerant.

250 Hudson is the tallest building within three blocks in all directions so the analysis clearly indicated that the roof experienced full sun exposure throughout the day and year. However, Symphony House was quite different. Located in Midtown Manhattan, Symphony House is surrounded by equally tall buildings. Therefore, the 9th floor roof experienced conditions ranging from full exposure to no direct sunlight at all. Specifically, the alcove on the north side of the building experienced no direct sunlight. Based on this understanding, the project focused on the southern roof along 56th Street. This analysis informed more than just plant selection – it determined the scope of the planted areas on the roof.

Daylighting analysis at Symphony House

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Green roof plan 250 Hudson (l), Symphony House (r). Not to scale.

Design

Once the opportunities and constraints were established, FXFOWLE worked collaboratively with Plant Fantasies to respond to Jack Resnick & Sons goals of creating a great amenity for building tenants. As owner and manager of both buildings, they carefully balanced design decisions with maintenance requirements throughout the design and construction process.

In designing each space FXFOWLE utilized the program requirements in order to develop an organizational diagram for each roof. At 250 Hudson, the focus was to create a large gathering space that celebrates the building's panoramic views. By contrast, at Symphony House the design intent established a series of inwardly oriented individual spaces within a serene landscape. Below are descriptions of the key aspects of the design process.

Programming

250 Hudson's focus was to create a large gathering space for office tenants. The largest building tenant has over 300 employees who come together for company events on the roof. On a daily basis, the furniture is used to divide the space into smaller seated areas, which tenants reorganize to fit their needs. A mix of four-person tables with individual chairs was provided so they could be moved independently. Also specified were Adirondack-style chairs made from 100% recycled milk jugs, with wide armrests that support a laptop.

At Symphony House the roof was designed quite differently. Family gatherings or a dinner party for 10-15 people are the roof's primary functions. To create more intimate spaces, the roof's circulation spine was positioned closest to the building and acts as a corridor separated from seating areas by vertical planted trellises. In a few years, the Clematis and Boston Ivy planted trellises will provide a visual separation between the circulation zone and each seating area. Furniture is a mix of rectangular dining tables with full length benches and large armless lounge chairs for reclining.

Plant Selection

In both projects, prior to planting the design team sculpted the beds to give them each their own distinct topography. To create grade changes, geofoam (expanded polystyrene) was inserted underneath the drainage mat. Geofoam was introduced because it is very lightweight, therefore reducing the weight of the growing media.

At 250 Hudson, the planting beds were conceived as a changing element. Therefore, seasonal color was a major consideration in

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Built up roofing for planting at 250 Hudson (l) finished results (r)

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250 Hudson and Symphony House completed projects

plant palette selection. To achieve a colorful variety of plants, three palettes were developed: one comprised of plants blooming or with vegetation in shades of blue and lavender, one with pink and rose tones, and one in yellow and golden tones. The areas of intensive plantings were then composed in large sweeps of each of the three palettes providing an interlacing of color that would achieve a good balance of all palettes throughout the seasons.

In addition to color and bloom time, drought tolerance and sun/shade requirements were important considerations. For example, the trellis planters wrap around the bulkhead with one side facing south in full sun and the other facing west with afternoon sun and partial shading. However, it was desirable to have the appearance of the two sides as consistent as possible. Boston Ivy and Clematis planting on the trellis was chosen to meet this requirement with plants that would perform equally well in both conditions. Though growth rates have differed between the two faces, in time both have flourished.

At Symphony House, plants were selected based on the microclimate of the roof and its full exposure to sunlight. Planted in pairs, multi-stem river birches provide rich texture and mix of stem and green leaves from top to bottom. Shallow-rooted perennials and sedums were chosen that could tolerate the windy rooftop. The flower color palette of primarily yellows and purples was timed to provide blooms throughout the growing season. Each of the native species selected for this rooftop garden was planted in massed swaths, layered within the slightly bermed planting beds. As each plant grew to maturity, the gardens have become soft multi-textured meadows that reflect the natural native landscape.

Maintenance

Jack Resnick & Sons' building maintenance staff and Plant Fantasies jointly maintain both green roofs. Responsibilities are clearly defined — the building staff addresses building elements such as cleaning roof drains, power washing roof pavers, removing trash from receptacles and general clean up around the planted areas. Plant Fantasies is contracted to provide weekly maintenance of the planted areas throughout the spring, summer and fall.

Irrigation

All of the planted areas at both 250 Hudson and Symphony House Street have been installed with an efficient drip irrigation system. The irrigation system is split into zones so that watering can be fine-tuned to the needs of the plants in each area, using as little water as possible. While the trees and raised trellis plantings are expected to always need additional water during the summer season, it is hoped that watering of the perennial and succulent areas of the green roof can be reduced to minimal supplemental levels once plants have established themselves.

Fertilization

Fertilizer is utilized as little as possible and using only organic sources where needed. Trees are fertilized twice annually, spring and fall, using Holly-Tone fertilizer.[2] Perennials and grasses have not been fertilized. The progress of these plants is being monitored to determine a regimen for fertilization or soil nutrient replacement.

[2] Holly-tone is derived from: hydrolyzed feather meal, pasteurized poultry manure, cocoa meal, bone meal, alfalfa meal, greensand, humates, sulfate of potash, and sulfate of potash magnesia.

> ***"The bottom line is 250 Hudson is full and all of the major tenants are requesting additional space. If we could raise the roof and put five more floors on the building, I think we'd rent them very quickly."***
>
> **– Burt Resnick, Chairman and CEO, Jack Resnick & Sons**

Weeds and Pests

As needs have arisen, weeds and pests are dealt with as naturally as possible. No herbicides are used at either location. Weeding is done by hand and with small hand-held cultivators weekly during the growing season and on a monthly basis during the winter. Ladybugs have been introduced to the beds at 250 Hudson Street when aphids were noticed on rose and milkweed varieties.

Results and Achievements

Office tenants at 250 Hudson use the roof for a variety of tasks throughout the day. One Human Resources Director conducts interviews on summer mornings. A prominent architect held his book signing on the roof. At lunchtime it is difficult to find an empty chair. The most unexpected result is the overwhelming number of requests to host private events on the roof. Throughout the spring, summer and well in to the fall building tenants reserve the roof space for their own functions.

250 Hudson has been awarded LEED Silver Existing Buildings and the 2010 Green Roof Award of Excellence from Green Roofs for Healthy Cities. The building also received a New York State Green Roof Tax Credit and is Energy Star-rated.

At Symphony House the response has been similarly positive. Completed in 2011, the roof has been used extensively by residents for meals and relaxation. The most unforeseen change occurred in the smoking habits of building tenants overlooking the green roof. Previously many tenants were accustomed to flicking their cigarette butts off their balconies onto the defunct jogging track. Now having seen the roof's transformation, the quantity of cigarettes requiring removal from the planting beds is steadily decreasing.

Building tenants aren't the only occupants on the roofs; they are also living ecosystems. Insects ranging from grasshoppers to bees inhabit the spaces. Birds frequent the roof because of the range of insects and flowering plants. Tenants occasionally witness hawks visiting the roofs.

The successes of the green roof retrofits at 250 Hudson and Symphony House can be attributed to a diligent analytical process that investigated the existing conditions of the context, building and roof, identifying opportunities and constraints. Allocating the additional time and effort to undertake a thorough feasibility study at the onset helped define the proper parameters that guided the project through its inception and beyond. A careful consideration of program, code requirements and plant type was carried out when developing the design. Finally, as with any living system, a highly collaborative team was key, particularly the commitment from the building management to proper ongoing maintenance practices.

Scott Melching *is a project architect and associate with FXFOWLE. As the firm's green roof expert, he leads the office's efforts to design and install green roofs on existing New York City buildings. He is a registered architect, LEED Accredited Professional and an accredited Green Roof Professional by Green Roofs for Healthy Cities.*

Jonathan D. Resnick *joined Jack Resnick & Sons, one of New York City's preeminent, family-owned real estate development and management companies, in 1996. He was named President in 2007. Mr. Resnick oversees the firm's vast portfolio of approximately six million square feet of commercial office and retail space, and approximately 900 rental apartments. He is directly involved with asset management, capital projects, leasing, new development, and the day-to-day operations of the firm.*

Teresa Carleo *founded PFI nearly 25 years ago and has over 30 years of experience in horticulture. Her passion for gardens and people has led to the creation of a design/build company specializing in urban gardens and urban green roofs. She also provides landscape contracting services for major projects throughout the Manhattan area. Teresa embraces all types of projects, from private spaces to large scale construction sites. She personally oversees all aspects of daily operations, from planning, design, estimating and personnel management, to sales and company financial requirements.*

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Symphony House before (l) and after (r)