## Deployment of Integrated Sustainable Roof Technologies in a Singular Project – National Institutes of Health, Case Study

## Ralph P. Velasquez Tremco Roofing and Building Maintenance Beachwood, Ohio, U.S.A.

## Keywords

Vegetative roof, green roof, living roof, solar, photovoltaic, cool roof, storm water

# Abstract

This case history will review the deployment of integrated sustainable roof technologies in a singular project at the National Institutes of Health (NIH) near Washington, D.C. The case study will review NIH's medical research library terrace design requirements and how they were resolved with multiple integrated sustainable technologies. The terrace roof had experienced limited use since its creation; now, with a new vigorous government focus on green initiatives, the library searched for a solution that would match its needs and the focus on sustainability.

The discussion will review various sustainable technologies selected to meet NIH's demanding needs and how they were integrated with a holistic approach. The paper will examine each technology; discuss trade-offs; examine budget constraints; and address factors involved in the final design selection.

Construction considerations will be highlighted during this discussion with a complete recounting of the construction process. With project completion, a review of the lessons learned will be shared with the reader. Furthermore, a two-year follow-up interview with the owner representatives will address lessons learned, a review of the project results achieved and awards NIH received.

## Author

Ralph Velasquez has worked in the roofing industry since 1978. During his career, he has worked with two U.S. roofing manufacturers and two roof consulting firms—one which he founded. Velasquez has worked on millions of square feet of roofing projects in the U.S. and been involved in international projects in Canada, India and Scotland. In addition, Velasquez has worked on numerous building envelope projects of various magnitudes in all market sectors.

Velasquez is the executive director of sustainability for Beachwood, Ohio-based Tremco roofing building maintenance division. Previously, he was the director for sustainable technologies, which includes building technologies based on the concepts of water, energy, carbon and other sustainable technologies.

Velasquez has been a member of the ASTM International Subcommittee E.06.71 (now E60 committee) for Sustainability since 2003. He previously chaired the Subcommittee for Life Cycle Costing established by Green Roofs for Healthy Cities, developing the world's first economic benefits calculator for vegetative roof systems. Velasquez is a former chapter board member and subcommittee co-chair for Advocacy & Public Policy in his home U.S. Green Building Council chapter in Middle, Tenn. He is a featured columnist for the website www.greenroofs.com.

Velasquez, originally from the Chicago area, has been married to his wife Lea for 34 years; has two daughters and three grandchildren; and currently resides in Nashville, Tenn.

### **National Institutes of Health Project**

The National Institutes of Health (NIH), Bethesda, Md., originally was founded in 1887 as a one room laboratory created within the Marine Hospital Service, Staten Island, N.Y. (1798). In 1891, the "Hygienic Laboratory" as it was then called, was moved to Washington, D.C., near the U.S. Capitol. After numerous expansions around Washington D.C., the current site was created and occupied from 1938-41.

The 27 institutes that constitute NIH are part of the U.S. Department of Health and Human Services, employing more than 18,000 people worldwide, with the largest concentration at the Bethesda site. NIH is the primary federal agency for conducting medical research—to the tune of \$28 billion dollars each year. Some of the institutes are involved in research for cancer, eyes, aging, allergies and infectious diseases, environmental health sciences and the human genome project.



(Overview of the Bethesda campus, courtesy of NIH)

There is one building unique to the campus. In building 10, lies NIH's Biomedical Research Library, an 8,000-square-foot library specifically used by NIH's research staff. Adjacent to the library is a 4,400-square-foot terrace originally designed to provide a usable patio space for patrons to enjoy the outdoors, relax, incubate ideas or just enjoy their lunches. Unfortunately, the space rarely was used because of the heat and glare

that often was present. Bethesda, located near Washington, D.C., and part of the Chesapeake Bay watershed, can be hot and humid during late spring through early fall, making this space quite undesirable.

In addition to the space's harsh structural realities, the terrace functioned as the roof to some underlying meeting rooms. A few years ago, the roof reached the end of its useful life and was reroofed with a liquid membrane and topped with concrete pavers, replicating the original design. Although there had been some discussion about doing "something else" with the terrace at the time of reroofing, there was little internal support or broad federal government vision for alternative ideas to the conventional re-roofing approach. That was true until Mary Hash, the library's administrative officer, decided to challenge the existing mindset by offering up some "radical" ideas.

This project originally was conceived in 2006 by Ms. Hash and the other owner's representatives, Ben Hope and Brad Otterson. Ms. Hash first conceived the idea of connecting the library to the outside terrace in a more direct and sustainable way. She also wanted to tie in a planned renovation of the library's interior to be in line with the broader goals of the institutes' multiple medical research missions. As discussions progressed within the library team and then more broadly with various stakeholders within the NIH family, it became apparent issues such as storm water retention and energy savings would need to be considered if the terrace was going to be funded so soon after the building was reroofed. As discussions widened, others involved with the library became aware of the project and added their ideas to an increasingly complex list of solutions that was desired and/or required in order to move forward.

Because of procurement desirability, the project also now needed to be tied in to two adjacent roofs that were scheduled for replacement. Also, there was a real concern about sending the right message about sustainability throughout the extensive NIH campus, so messaging regarding the project would be an important requirement.

Armed with these project requirements, the NIH library team began to research the options available to meet such a wide and varied list. It quickly became apparent sustainable concepts such as vegetative roof systems would be key components when redesigning the terrace. Once vegetative roof systems became part of the team's discussion, the team quickly realized it would need outside expertise that could assist during the process and perhaps offer additional solutions that would meet its other objectives.

The team first turned to its on-site general contracting firm, which had experience with multiple projects on NIH's campus and would have the reach and capability to tap into the marketplace for any additional help. At the same time, Ms. Hash brought up the topic to their onsite contractual roofing partners, who had been involved in the terrace reroofing a few years earlier. After meeting with the on-site partners, the NIH team decided the roofing partners had the expertise required and should lead the project design and installation. The general contractor was retained as the primary contractual partner and would perform any work outside the roofing team's scope. This "two-headed" prime contractor arrangement would prove to be a bit cumbersome from a construction perspective; however, from a procurement and funding perspective, it made sense to NIH.

The roofing team's first steps were to sit down with NIH to make sure all NIH goals would be met and to discuss what else could be done to more fully meet their objectives. The key objectives included the following:

- 1) Storm water capture—The library staff wanted to make sure the roof could capture all the storm water from the terrace roof as a minimum.
- 2) Improving the comfort factor for those who want to use the terrace
- 3) Improving the connectivity of the terrace to the library's interior
- 4) Somehow creating a connecting message between NIH's mission and the roof
- 5) Looking to further improve energy efficiency, if practical



(Terrace before being made more sustainable in nature)

With these key imperatives, the roofing team and NIH discussed various technologies that would help achieve these goals. To help expand the design process, a landscape architect with vegetative roof system experience was added to the roofing company's internal sustainable staff, which consisted of an environmental horticulturalist, architect and former vegetative roof consultant. Also added to the team as needed were a solar engineer, mechanical engineer, structural engineer and several fabricators or installers. To meet the storm water objective, a vegetative roof system would be part of the solution. This would be coupled with a storm water capture system that would work with the vegetative roof system. In addition, the two adjoining roof areas scheduled for work also would capture storm water and feed into the system, providing enough water for the vegetative roof system and the living wall system.

To improve the comfort of this space—bordered by three brick walls, which acted as heat sinks and passive heating sources surrounding the terrace - living walls would be constructed to shade the brick and cool the air space over the terrace. In addition to living walls, new shade structures would replace the few umbrellas present in the space. The shade structures not only would provide shading for those using the space but provide potential for integrating design elements that could speak to NIH's mission of medical research. The vegetative roof system would provide additional cooling, as well as visual and audio elements that could improve comfort by their sheer presence. And more and better-placed seating that was sustainable would be added.

To improve the connectivity between the exterior and interior spaces, color schemes from the interior palate on outside elements would be used, such as in the shade structures, flowering plant species and other hardscape components. A second door in the center of the space with a small walk bridge over a lower grill-covered mechanical space would be added. The window treatments on the interior design would be modified to provide better visual access to the newly designed terrace space. Educational signage in the interior would be provided that would tie into the exterior space.

To provide a connected message between NIH's mission and the terrace, plant material in the vegetative roof system that is used in the research programs of building 10's biomedical mission would be implemented. The shade structures would be designed to mimic the DNA structure of the human body, reflecting the human genome research conducted on campus.

To improve energy efficiency if practical, cool roof technology would be applied to the adjoining two roofs being done at the same time as the terrace roof. Photovoltaic panels would be installed on one of the adjoining roofs to power the pumps of the storm water retention tank, the path lighting on the vegetative roof and the pumps of a water feature on the vegetative roof.

In addition to these concepts, it was suggested and ultimately decided the existing insulation and some of the pavers could be reused, improving the reuse of existing materials. The existing seating also could be refurbished and repurposed, adding only new materials as needed to improve the terrace's seating capacity. New wood materials would be from certified sustainable forests. All these features affected virgin materials use, landfill reductions and greenhouse gas emissions. To encourage recycling, new bins also would be added to the site at the terrace's exterior access points.

With the key goals in mind, the team went to work on the design. Several renditions were reviewed that met the project's key imperatives and were acceptable to all the stakeholders. One concept that specifically had significant internal support initially, involved the use of a double-helix DNA stand design in the shade structure. In addition, a planned water feature was modified to include a water fountain from another NIH site, which was being donated to the project.



(Original helix designed canopy)

With this basic design in mind, the team began to plan the budget. The first challenge in the budgetary process was the signature double-helix shade structure. Pricing for the structure, though anticipated to be high because of its custom nature, ran into two difficulties. The first was the cost because the first cost estimates came back three times higher than anticipated. The other issue was scheduling because the few local companies capable of creating the structure would need about a year to deliver the finished project, which was unacceptable to the NIH. After reworking the design and working with various suppliers, it was decided the concept would need to be abandoned and a new design created. The roofing company conducted research and a semicustom design was located that was acceptable to NIH and fit within the budget constraints.

The next hurdle was the fountain, which had been donated by another facility on NIH's campus. The fountain originally was a gift to NIH and when the original donor became aware of the intent to relocate the fountain, he did not support the idea. After much discussion, NIH decided to relocate and repurpose the fountain elsewhere on campus.

A scaled-down water feature then was designed and proposed for the terrace. This obviously put increased pressure on the budget because the original fountain was to be donated.

To accommodate the increased budgetary pressures, NIH decided to phase in the introduction of the living walls. Two walls would be done during the initial project, and the remaining two walls would be done in a follow-up project during the second year. The two walls receiving the most direct sunlight and thereby creating the most direct heat sinks would be included in the initial package. There was some additional savings via a scope reduction of the knee wall that would have lined one side of the fountain. With the fountain's removal, the existing wall could be kept as is. With the key design issues worked out, budgets were reworked and final hard numbers could be obtained from all subcontractors. After much consternation, a final project cost was obtained and a notice to proceed awarded by NIH. The project finally was ready to begin! Construction was substantially completed in four weeks.

(Click on attached construction photo journal) - 66 tons of material recycled or reused



http://nihlibrary.nih.gov/Documents/terrace\_photos.pdf



(Plaque at the ribbon cutting ceremony)



(Overview of roof at completion)



(Eye level view of recently completed roof - growing media ranges from 3-10")



(Completed project, view from front entrance to terrace)



(Wires for the living wall)



(4kW solar array on adjoining roof powers pumps, water feature and lighting)



(1,200-gallon cistern, used to irrigate VR and educe effects on the Chesapeake Bay Watershed )

Plant list below includes drought-resistant species, traditional perennials and a zone for tropical plants being researched for medicinal value.

#### List of Plants on the Green Terrace NIH Library

#### Tall Perennials:

Aster cordifolius Aster divaricatus Tradescantia Amsonia tabernaemontana Solidago caesia Pycnanthemum muticum Eupatorium rugosum Deschampsia cespitosa

#### Groundcovers:

Sagina subulata

#### Medicinal/other:

Hypericum talisinum Heuchera sp Penstemon digitalis Polystichum acrostichoides Epimedium Euphorbia diglossii Tiarella cordifolia Carax pensylvanica

### Vines:

Akebia quinata Lonicera sempervirens

#### Sedums:

- S. album
- S. floriferum
- S. Kamtschaticum
- S. rupestre S. sexangulare
- S. spurium S. pulchellum
- Talinum clycinum
- Allium schoenoprasum

November 9, 2009

The project substantially was completed in late 2008 with a dedication and ribboncutting ceremony on Earth Day 2009. The owners were pleased with the final result and looked forward to having the terrace used more extensively than in the past. To determine whether the desired results were achieved, a follow-up interview with Ms. Hash was conducted Sept. 20, 2010.

The first good news Ms.Hash (library administrative officer) shared with us was that the project had been awarded the Health and Human Services Green Champion Award for Sustainable Building Design for fiscal year 2009. NIH received the award June 10, 2010.



Ms. Hash told us the project was a hit with all the researchers that typically used the library and that others on campus were finding their way over to the building to access the terrace; she observed that many more young people were using the space than previously. Ms. Hash also said that the patrons had expressed on numerous occasions they feel more connected to the space than they had before. Now, almost 2 years old, following are the results of this effort.



(Overview from upper roof – new reflective white gravel roof systems in place)



(Overview of shade elements and plant research area)



(Overview of fountain area)



(Overview of sedum area)



(Close up view of intensive planting area)



(Overview of intensive/semi-intensive planting area)



(Great color)



(Plant close-up)



(Plant close-up)



(Living wall starting to grow – one year growth)



(Overview of solar panels used for pumps, water feature and path lighting)



(Water irrigation storage tank feeds sub-surface irrigation system)



(Completed project, two years later - Sept. 2010)