

VEGETATIVE ROOFS:



As a roofing technology, vegetative roofs have been widely installed in the United States for only about the last 20 years. The market acceptance of vegetative roofing continues, and the industry has gradually moved beyond the knee-jerk reaction held by many that vegetative roofs were “problems waiting to happen.” In fact, owners, architects, and the construction industry generally, are coming around to the position that fueled the development of the vegetative roofing industry in the first place. That is, that a properly designed, professionally installed and maintained vegetative roof offers benefits that demonstrably enhance overall roof performance.

WHAT GOOD DO VEGETATIVE ROOFS DO?

Extend Roof Longevity

Vegetative roofs greatly extend roof service life by protecting the roofing from ultraviolet (UV) exposure and extremes in thermal cycling, much in the same fashion as an inverted roof membrane assembly (IRMA) or protected membrane assembly offers protection from those elements. Because the roof field of a vegetative roof is covered, routine roof observation and maintenance are simplified, as there is little uncovered, unprotected roofing to observe and maintain. The only roof areas unprotected by the vegetative roof are the perimeters, and at curbs and flashings—primary areas of concern whether the roof is vegetated or not. Vegetative roofs do require regular maintenance, but this is mostly limited to

keeping the roof free of weeds and applying one or two light applications of organic fertilizer annually. Under normal circumstances, chemical herbicides are not, and should not, be used on vegetative roofs, and they could even cause chemical reaction issues with the roofing.

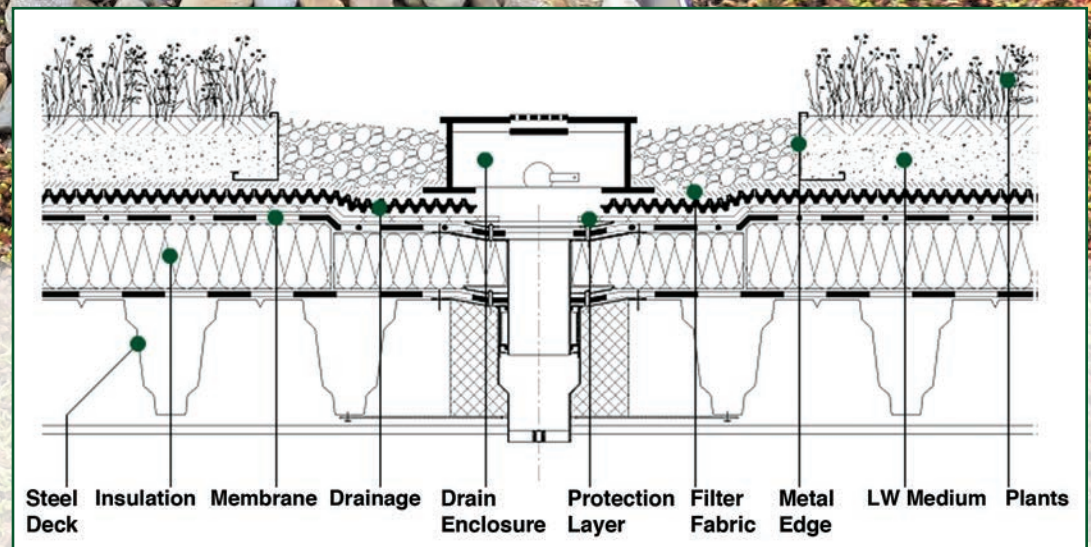
Manage Stormwater

Vegetative roofs manage stormwater runoff better than conventional roofs, and vegetative roofs are recognized as accepted stormwater mitigation remedies by many municipal and governmental authorities. In minimal rain events ($\frac{1}{2}$ in. or less), precipitation may be completely captured in the growing medium on the vegetative roof, eliminating runoff altogether. During more significant rain events where stormwater exceeds the water-holding capacity of the

A Problem, or the Future?

By Jon Crumrine, RRO, GRP

Figures 1A and 1B - This drain detail indicates the components typical of a complete vegetative roof assembly. The photo shows the finished drain.



soil, runoff velocity is dramatically reduced because the water must first percolate through plants, soil, and other components before it leaves the roof.

Additionally, the process of filtering runoff through the vegetative roof has the effect of removing particulates and organic pollutants from runoff and providing a first level of “treatment” by cleaning it and improving its chemical quality. These benefits may not be of extraordinary interest to building owners, but they are critical to public entities responsible for public works infrastructure and environmental quality.

Improve Rooftop Environment

By helping moderate rooftop temperatures, vegetative roofs enhance rooftop

environmental conditions. Vegetative roofs reduce solar thermal gain in the roof and increase albedo (the fraction of solar energy reflected without being absorbed), while plants transpire moisture, providing a measure of evaporative cooling. The net effect of these is a reduction in rooftop ambient air temperatures, which may lead to a commensurate reduction in overall urban heating. Photovoltaic (PV) panels and vegetative roofs cohabit and function well together,

and lower rooftop air temperatures may help PVs perform more efficiently.

Studies have found that residents of buildings that incorporate environmentally oriented design elements, including vegetative roofs, may have higher tenant satisfaction rates than buildings without them. This is particularly true for buildings where the vegetative roof is created as an amenity space, available for use by residents and visitors. But whether the roof is publicly



accessible or not, a properly performing vegetative roof is a far more hospitable alternative to a conventional roof.

Vegetative Roofs, Cool Roofs, and IRMA Assemblies

Highly reflective or “cool roofs” are very popular and claim similar benefits to vegetative roofs regarding their ability to reduce roof thermal gain and lower rooftop air temperatures. Cool roofs are also much less

expensive to install than vegetative roofs. However, cool roofs become dirty quickly without frequent cleaning and regular maintenance, and without these, the cool roof’s reflectivity and albedo suffer greatly, making them far less “cool.” A vegetative roof’s albedo and reflectivity performance are not negatively impacted by the factors affecting cool roofs, and what’s more, cool roofs offer no benefits relative to roof longevity or stormwater management.

Inverted roof and protected membrane assembly roofs offer the benefits of membrane protection and extending roof service life. Vegetative roofs are commonly installed on IRMA roofs above the insulation as the final top assembly. An inverted membrane assembly roof that is planted gives the roof the stormwater management benefits associated with vegetative roofs, and is certainly a more aesthetically pleasing space with vegetation than without.



Figure 2 – Proper nonvegetated perimeter details for skylights and at parapets.

WHAT ARE THE KEYS TO A SUCCESSFUL VEGETATIVE ROOF PROJECT?

Hire an Experienced Contractor

It is essential that vegetative roof installation contractors be experienced with rooftop landscaping and have a verifiable track record of successful projects of the size and scope of projects under consideration. Contractors should be carefully qualified to make sure they are approved to install the specified vegetative roof system. What's more, experienced contractors with a track record of success will have demonstrated they know how to work on roofing without doing damage, which may be the single most important qualifying characteristic. Vegetative roof construction itself is not terribly complicated, but the site conditions, sequencing, hoisting/loading, and worker safety issues can be extremely complex, and the risks severe. An inexperienced, "low-bid" contractor experimenting on your roof can be a recipe for disaster downstream. Jobsite inspections and work-in-progress inspections during construction are critical to make sure the vegetative roof system is being installed per specifications and manufacturer's instructions.

Make Sure the Design Is Complete

Make sure the vegetative roof design includes all the essential vegetative roof system components, including but not limited to a protection layer, drainage layer, filtration layer, soil, and plants. See *Figures 1A* and *1B*.

Special attention should be paid to the vegetative roof system's drainage components, as well as how the roof drains generally, as poor drainage causes more vegetative roof failures than any other single cause. Provide nonvegetated areas at parapets, drains, curbs, and larger penetrations, and fill them with 1- to 1½-in. washed round rock the same depth as the growing medium (see *Figure 2*).

Paver pathways connecting roof access points with rooftop mechanicals and other systems should be included in the design. Paths provide access to rooftop systems for maintenance without trampling the vegetation or damaging vegetative roof or rooftop irrigation components (*Figures 3* and *4*).

A protection layer between the roof membrane and the components of the vegetative roof system is always a good idea, and there are a variety of serviceable mate-

rials available to perform this function. If the roofing is bituminous, a root protection layer is mandatory to keep roots from potentially penetrating the membrane. The vegetated and nonvegetated areas of the roof should be designed to cover as much of the total roof area as possible in order to maximize the benefits of protecting the roofing. If some roof areas are covered and others left uncovered, the membrane will age at different rates, which could lead to problems later at the transitional areas between them.

Vegetative roof designs should also try to anticipate areas adjacent to windows or metal walls where reflected heat may become an issue. These areas may be better left as nonvegetated spaces rather than struggling to keep plants alive in areas inhospitable to them. Likewise, the succulent groundcover plants that typically predominate the extensive vegetative roof plant palette do not prefer environments that are constantly wet. Roof areas that are continuously in shade or in exposures that don't allow them to regularly cycle wet and dry may require special design consideration.



Figures 3 and 4 – Paver path under construction (left) and after planting is complete (below). Photos and diagrams courtesy of DiademUSA.



Roof System Choices

Vegetative roofs may be successfully installed over almost any type of low-slope roofing system. However, since one of the primary benefits of having a vegetative roof is maximizing roof longevity, skimping on the membrane choice is not an advisable strategy. The best membrane selection for beneath the vegetative roof is the best and most durable roof the budget allows, installed by a qualified, experienced contractor. Once installed, have the membrane thoroughly tested for leaks to prove the roof is watertight. Then, have a competent, experienced contractor install the vegetative roof, and the result can be an extension of the roof's lifespan by a factor of two or perhaps even longer. Contrary to popular mythology, vegetative roofs do not cause roof leaks, and there is no reason a roof tested to be watertight should not remain watertight for many years after the vegetative roof system is installed.

Contracting

Ideally, the roofing contractor and the vegetative roof contractor should be under the same contract, together as a team. The two parties need to be synchronized with one another and have a good and trusting working relationship. Also, the roofer often has equipment (for example, a crane for hoisting) that can be extremely helpful to the vegetative roof contractor. Coordination between the roofer and the vegetative roof contractor happens much more naturally if the two are under the same contract, and greatly reduces the likelihood of any finger-pointing issues down the road.

Maintenance is Mandatory

Vegetative roof maintenance is very important, especially during the initial, first-year, post-installation establishment period. Contractors bidding for vegetative roof projects should be required to provide qualifications and proof of vegetative roof maintenance experience, and two years' post-installation maintenance should be written into the project specs. Vegetative roof maintenance is limited, basically, to keeping the plants healthy and the weeds under control, so vegetative roof maintenance is about diligence as much as anything else.

Managing the irrigation system, including starting the irrigation in the spring/summer and winterizing the system in the fall, also falls under the heading of vegetative roof maintenance. Rooftop irrigation systems are far more susceptible to winter freezing than on-grade irrigation systems, so blowing any remaining water out of the irrigation lines in the fall as part of the winterization process is particularly important. The last major vegetative roof maintenance item is annual application of organic fertilizer. Any granular, slow-release organic fertilizer with a formulation of 7-2-4 (nitrogen, phosphorous, potassium) or similar will suffice. Nonorganic or synthetically derived fertilizers or soil amendments should be avoided.

Irrigation Basics #1

In several geographic regions of the country, supplemental water in the summer is necessary to keep the vegetative roof performing as designed. If the vegetative roof is irrigated, the practical realities of the engineered soil mixes used on vegetative roofs need to be accounted for. To keep it lightweight, the growing media used on vegetative roofs are highly mineral in composition (pumice, expanded shale, or clay) with a relatively large granular size. This being the case, the engineered media used on vegetative roofs possess little capillarity, or the ability to move moisture upward or laterally through the medium. In addition, the highly mineral, lightweight engineered media drain much more rapidly than non-engineered soils. If the vegetative roof is irrigated by a drip irrigation system, the roof typically will not receive moisture in a uni-

form fashion, but often in strips of wet and dry. Attempting to achieve uniform coverage on a vegetative roof with drip irrigation requires the system to be run much longer and more frequently than would be the case with other types of irrigation systems. Consequently, drip irrigation, as it currently exists, generally is not recommended for extensive vegetative roofs. This is the case even though it was the dominant choice for vegetative roof irrigation as recently as ten years ago. Rather, experience has shown that pop-up spray systems using micro-rotator-type nozzles are usually the superior choice for irrigating extensive vegetative roofs. The micro-rotator nozzles are highly water-efficient by design and provide excellent uniformity of coverage. Plus, micro-rotator nozzles throw a larger water droplet than typical spray nozzles, making them less susceptible to wind throw, which is very helpful on rooftop applications.

Irrigation Basics #2

The vegetative roof irrigation system should be designed on its own stand-alone irrigation controller rather than added to the same control system as the rest of the

site landscape. Combining the two may seem to make sense on one level, but the reality is that the water requirements of the vegetative roof are very different from those of the typical site landscape. The problem is compounded by the fact that maintenance of the vegetative roof and maintenance of the site landscape are typically the responsibility of different entities. Having multiple parties manage the same irrigation control system almost inevitably causes errors in irrigation programming and scheduling. Vegetative roofs have failed because irrigation programs were mistakenly changed—or even turned off—by individuals lacking a complete understanding of the situation. Adding a stand-alone controller for the vegetative roof eliminates the problem and doesn't add significantly to the overall project budget.

WARRANTIES AND THE FEAR OF ROOF LEAKS

To offset fears of roof leaks, most roofing/vegetative roof system manufacturers

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offer “full-system” or “overburden removal and replacement” warranties. These warranties cover removal of the overburden (i.e., the vegetative roof system) and its replacement if problems occur with the roof. The warranties themselves can be expensive to purchase, and qualifying for the warranty often requires purchasing proprietary or overpriced materials.

Rather than buying a full-system warranty, a less expensive approach to managing roof leak risks may be including an electronic leak detection (ELD) system in the project program. ELD systems can be highly effective when installed by an approved contractor, and in the hands of an

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experienced technician, finding leaks can be a relatively straightforward process. Once the location of the leak is pinpointed, pulling back the vegetative roof and exposing the area in need of repair is an easy proposition for an experienced vegetative roof contractor. However, it's worth pointing out again that roof problems most frequently occur at flashings, penetrations, and curbs, and not in the field of the roof—and this is the case whether the roof is vegetative or not. The overall fear of roof leaks in association with vegetative roofs is very often greatly exaggerated.

SUMMARY

Misunderstanding about vegetative roofs remains an issue among many in the roofing and construction industry; and for some, the idea of soil and plants on the roof may

never seem reasonable. However, manufacturers of vegetative roof systems, designers, consultants, and contractors have developed a large body of knowledge and experience concerning the installation and care of vegetative roofs. Millions of square feet of vegetative roofs have been successfully installed in the U.S. and around the world, proving there is no basis for the perception that vegetative roofs are “problems waiting to happen.” Vegetative roofs and on-structure landscaping are viewed by many architects and urban planners as key features of modern urban construction. Technologies like vegetative roofs and living walls are bound to play an increasing role in the high-performance building envelopes of the future. Using the aforementioned guidelines as a roadmap can greatly increase the likelihood of successful projects. 



Jon Crumrine

Jon Crumrine is vice president of business development for DiademUSA, a manufacturer of vegetative roofing and roof safety systems. He has been involved with green roofs since 2002, most

notably as the president of Envirosapes Northwest, where, between 2008 and 2016, he was engaged in building and maintaining commercial vegetative roofs throughout the Pacific Northwest. Crumrine is a certified Green Roof Professional and a Registered Roof Observer—one of few professionals to hold both credentials.

BLS STUDY TOUTS CONSTRUCTION PRODUCTIVITY

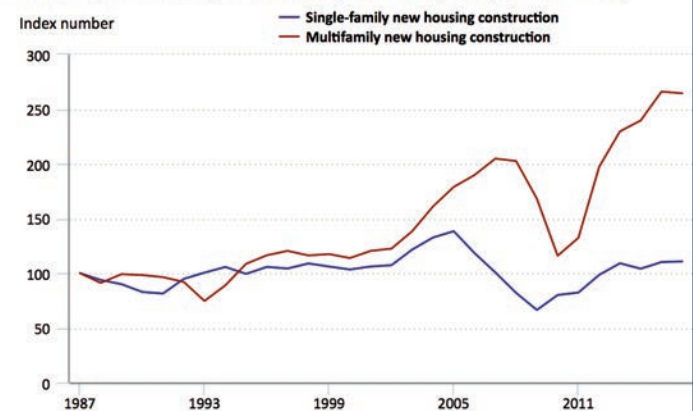
A new U.S. Bureau of Labor Statistics (BLS) study, “Measuring Productivity Growth in Construction,” shows impressive productivity gains in an industry that had previously been thought to show negative or zero productivity growth. “By focusing on specific output indexes for subsectors of construction, BLS avoided relying just on the change in cost of the materials that go into producing that product and also avoided blending outputs that may have had very different price changes,” said Ken Simonson, chief economist with the Associated General Contractors of America in explaining the new results. Three out of four of the construction sectors analyzed showed productivity gains: single-family, multifamily, and industrial. Only highway and related construction was the exception.

BLS reported that from 1987 to 2016, labor productivity in single-family construction increased an average of 1.1% per year, while multifamily construction increased an average of 3.7% per year. Industrial construction, analyzed from 2006 to 2016, improved at an average annual rate of 5.3%.

The importance of subcontractor labor in the factoring was noted. Subcontractor labor accounts for 44.2% of total labor hours in single-family construction, 74.5% in multifamily construction, and 84.9% in industrial construction.

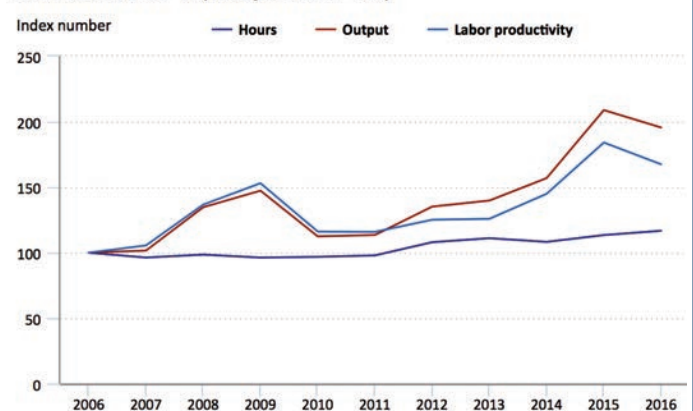
Read the complete report at: <https://www.bls.gov/opub/mlr/2018/article/measuring-productivity-growth-in-construction.htm>.

Figure 3. Index of productivity (output per hour) in single-family and multifamily new housing construction, 1987–2016 (base year 1987 = 100)



Click legend items to change data display. Hover over chart to view data.
Note: Recession periods are July 1990 to March 1991, March 2001 to November 2001, and December 2007 to June 2009, as determined by the National Bureau of Economic Research.
Source: U.S. Bureau of Labor Statistics.

Figure 6. Index of hours, output, and labor productivity in industrial construction, 2006–16 (base year 2006 = 100)



Click legend items to change data display. Hover over chart to view data.
Note: The recession period was from December 2007 to June 2009, as determined by the National Bureau of Economic Research.
Source: U.S. Bureau of Labor Statistics.