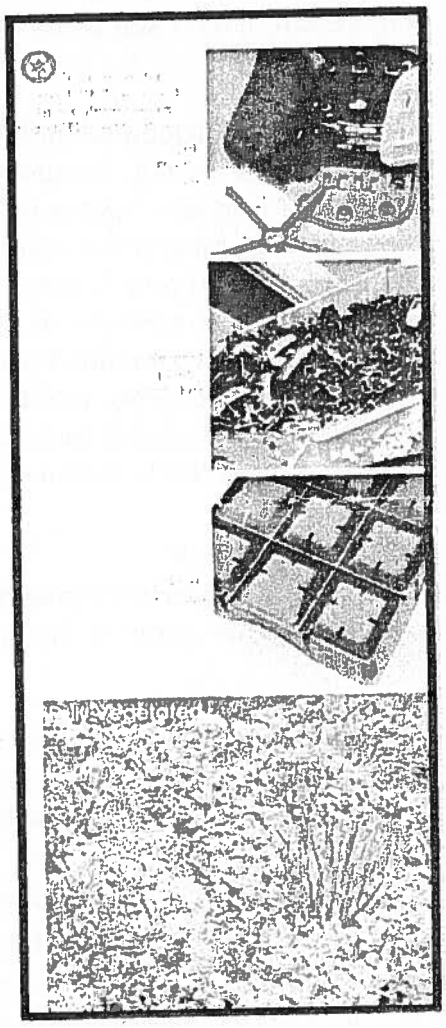
LiveRoof

Social Benefits

Improved livability.

Improved physical and mental health from exposure to nature.

Increased sense of pride and place, levels of trust, civic participation, less violence, aggression, vandalism, and littering.



Aesthetic Benefits

Green roofs are much better looking than asphalt, gravel or tar.

Natural views create more productive, healthy, happy, creative, relaxed people.

Green roofs expand the usefulness of buiidings via patios, gardens and vistas.

Environmental Benefits

Urban Heat Island Mitigation

The urban heat island effect is the temperature difference between urban areas and their rural surroundings. The temperature differential causes air currents and dust, and even contributes to violent weather events within urban settings.
Green roof vegetation helps by cooling the air, slowing air movement and acting as a substrate for pollution to settle out and detoxify.

Noise Reduction

Plants, soil, and air trapped in the soil are great acoustic insulators. Tests indicate that green roofs can reduce indoor sound by as much as 40 decibels, which is of great benefit to occupants of buildings affected by airports, industry, trains and traffic.

Innovation in Design

LiveRoof systems may contribute to innovation and design credits in a number of obvious and not so obvious ways. By helping to create a better work environment, LiveRoof can create greater workplace productivity. LiveRoof installations can be used for meetings and relaxation, education, creating beautiful vistas, and for fostering better health, reduced healing time, and increased positive social interaction. Green roofs may be integrated with patios and outdoor kitchens. For advanced green roof innovation, owners may tailor roofs to grow herbs and vegetables, farm honeybees and create high quality honey, reduce exterior sound, to sequester carbon, and to increase the overall shared "green" footprint of the neighborhood when added to adjoining buildings. One LiveRoof owner, Haworth Corporation, even used some of their own waste plastic in the creation of their LiveRoof modules!

Innovation can include Wildlife Friendly Design, Plant Preservation, Restorative Use of Vegetative Waste (e.g. compost and compost tea), Non-Chemical Water Treatment, the buffering of acid rain, and earth friendly growing and maintenance methods. Indeed, innovation can take into account that LiveRoof is grown using Integrated Pest Management (see LEED SS/EQ) and in some cases (e.g. our Midwest growing operation) using Natural Predator Pest Management or even organic growing methods. Likewise, once installed, LiveRoof may be maintained using Organic Landscape Management, Biological or Integrated Pest Management (IPM), and Eco-Roof Monitoring. The sky is the limit when it comes to innovation, and it seems that everyday someone thinks of some new way to employ LiveRoof toward the betterment of people and the environment.

Money Savings

LiveRoof modules help to save money which can be applied to other sustainable building methods in other areas of the project.

The Bottom Line

The bottom line is that LiveRoof can contribute to over 20 LEED points, depending on the size of the green roof and the degree to which the various features described above are incorporated into the overall building design.

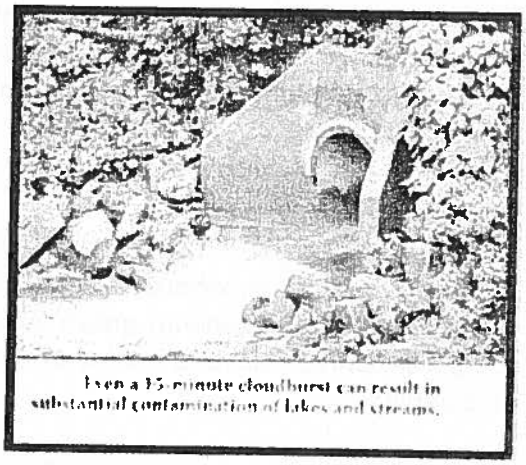
Regional Priority Credits

Potential Credits: 1-4 Possible Points

Depending on geographic region, additional points may be available for having a green roof. LiveRoof is the most advanced green roof system on the market, offering a significant LEED impact compared to other green roof systems

Conservation of Municipal Septic Systems

Sponging up excess rainwater means municipal septic systems do not have to be expanded as much. It also means reduced overflows as well as reduced pollution and associated costs.



Even a 15-minute cloudburst can result in substantial contamination of lakes and streams.

Extension of Roof Life

Plants and soil act as a protective shield from the elements.
This means:

- No U.V. radiation/photo degradation of roofing components.
- Minimal thermal contraction and expansion (green roofs can reduce temperature fluctuations by as much as 90%). Studies show that on a sunny 95°F day, conventional rooftop surfaces can reach 175°F. Green roofs bring these temperatures in line with the ambient air temperature.
- Protection from drying winds.
- Protection from mechanical damage.
- Reduction or elimination of cracks and leaks.
- Potential 200% - 300% extension of membrane life expectancy.

Energy Conservation

The evapotranspirative effect of the plants and four inches of growing medium typically reduces indoor temperatures 6 to 8 degrees during warm/hot weather and can reduce air-conditioning costs 25 to 50 percent in single story buildings. This not only allows for ongoing cost savings but an initial reduction in the size of the required air conditioning equipment.

Minimal insulation (R-Value) exists during cool or winter weather. The pore space of the growing medium tends to be more water saturated at this time, and the plants won't be as large and therefore will not trap as much air (essential to insulation value). But, in snowy winter locations, the vegetation helps to trap blowing snow which adds insulation value.

LiveRoof and LEED Credits

Leadership in Energy and Environmental Design (LEED) is the green building rating system developed by the United States Green Building Council (USGBC). The LEED system's intent is to provide a standard certification process that registers and quantifies buildings for

design and construction methods that promote five key areas of human and environmental health: sustainable site development, water savings, energy efficiency, materials selection, and indoor environmental quality. LEED provides a roadmap for measuring and documenting success for every building type and phase of building lifecycle. Our advanced

green roof system can help you achieve LEED certification in several categories—above and beyond that of just any green roof system. Below are the major categories of the LEED BD+C (2009 edition) rating system and potential credits that can be influenced by the LiveRoof system.

Sustainable Sites

Protect or Restore Habitat and Maximize Open Space

If you think about it, wherever there is a building, there once was some type of vegetation. Green roofs help to reclaim green space, and in the process they provide habitat (for songbirds, butterflies and a host of other invertebrate species) therefore helping to promote biodiversity.

Potential Credits:
SS 5.1 Site Development,
Protect or Restore Habitat, 1 point
SS 5.2 Site Development,
Maximize Open Space, 1 point

Storm Water Design

LiveRoof systems help to prevent excess storm water discharge. They also help to filter and detoxify storm water by removing suspended solids and other pollutants.

Potential Credits:
SS 6.1 Quantity Control, 1 point
SS 6.2 Quality Control, 1 point

Heat Island Effect

Typically used on roofs and sometimes at grade, LiveRoof significantly reduces roof temperatures during the summer months and the USGBC specifies green roofs as a means of mitigating the urban heat island effect.

Potential Credits:
SS 7.1 Heat Island Effect–Non-Roof, 1 point
SS 7.2 Heat Island Effect–Roof, 1 point

Water Efficiency

Water-Efficient Landscaping

When vegetated with drought resistant LiveRoof plants, LiveRoof installations require little irrigation. In comparison to conventional plant material, LiveRoof plants require significantly less than 50% of typical irrigation, and in some climates can thrive with little or no supplemental irrigation. Additionally, the LiveRoof growing medium acts as a sponge to collect and filter excess rainwater. In heavy rains, of course, runoff will occur and this can be channeled into a cistern for reuse on the LiveRoof, to a rain garden, or to parts of the ground-level landscape. Effective use of such collected water can contribute.

Potential Credits:
WE 1.1 Water Efficient Landscaping,
Reduce by 50 %, 2 points
WE 1.2 Water Efficient Landscaping,
No Potable Use or No Irrigation, 4 points

Energy & Atmosphere

Optimize Energy Performance

The LiveRoof system offers substantial energy saving benefits. The precise benefits will vary with climate, for example in the northern temperate zone the savings of energy expended on air conditioning is expected to exceed 25 percent. In warmer climates, the energy savings period will last for a longer percentage of the year. In either case, the exact savings will be based upon site, exposure, atmospheric conditions, and moisture content of the LiveRoof soil. During the winter, because the LiveRoof is relatively moist, its R value will be about 1.9.

Potential Credits: EA 1.1 to 1.19, 1 to 19 points

Materials & Resources

Construction Waste Management

Your LiveRoof® grower is happy to take back the removed soil elevators from the job site and recycle them. The installer need only bag them and send them back with the truck driver.

Potential Credits: MR 2 Construction Waste Management, 1 to 2 points

Recycled Content

LiveRoof modules are composed of 100 % recycled polypropylene (avg. 10% post consumer, 90% post industrial), and in many cases the LiveRoof soil contains recycled materials such as compost or reclaimed mineral aggregates (verify with individual grower). By using recycled plastic and reclaimed components, LiveRoof helps to make good use of resources that otherwise might go to a landfill.

Potential Credits: MR 4.1-4.2 Recycled Content, 1 to 2 points

Regional Materials

LiveRoof modules are manufactured within a 15-mile radius of distribution and LiveRoof plants are grown at local nurseries, typically with soil components from that region.

Potential Credits: MR 5.1-5.2 Regional Materials, 1 to 2 points

Rapidly Renewable Materials

LiveRoof plants, for the most part, are plants that are grown and repeatedly harvested like bamboo. In other words, the source plant material is harvested without disturbance to the soil and without the need to repeatedly replant the original plantings. This has the effect of reducing carbon and fertilizer inputs and protects the farmland from erosion.

Potential Credits: MR 6 Rapidly Renewable Materials, 1 point

Fire Prevention

Succulent green roof plants help reduce the risk of fire. See A&E section.

Water Conservation/Reduction of Storm Water Runoff

The soil in green roof systems acts like a sponge and absorbs excess rain water. Research has shown that extensive green roof systems can reduce runoff by up to 90+% annually (varies with climate, soil and pitch of roof).

Green roofs reduce the impact of each new building on the municipal storm drainage system and surrounding watershed. They reduce flooding, erosion and artificial heating of water which helps preserve fisheries and other aquatic life.

Green roofs reduce the need for on-site storm water management systems and according to Seattle based Magnusson Klemencic Associates, under certain conditions, can offset the cost of a green roof by 30 to 60%. When combined with an effective rain garden (bioswale), green roofs can make it possible to have zero discharge of rainwater from the site, therefore saving money by not having to connect to the storm sewer system.

Green roofs filter water prior to returning it to the aquifer. They buffer acid rain and remove nitrate pollution as water slowly percolates through the soil.

What runoff remains will usually occur hours after peak flows, providing additional time for sewer systems to handle the runoff burden from impervious surfaces.

Habitat Recreation

Plants and soil help recreate habitat for butterflies.

Financial Benefits

Political Correctness

With an emphasis on recycled components, energy conservation, sustainability and minimal environmental impact (via development), green roofs score points with city planners, the community and tenants. This is oftentimes rewarded with zoning that allows for more intensive development. Building with green roofs may also receive tax credits or municipal grants and typically will command higher selling and rental prices.

Suburban Tire Store

Projects Counter: 770 Projects
Total Sq Ft: 2,431,781

Architecture & Engineering

Plant Basics

The LiveRoof Standard and LiveRoof Lite systems are "Extensive" green roof systems. In other words, their soil depth is less than 6 inches. And, while extensive green roof systems optimize evaporative cooling and storm water management (in part because they can dry down between rain events), their shallow substrate depth means that the plants they can support must be extraordinary at resisting drought. Practically speaking, the plants that work best in "extensive" green roofs must be exceptional "water conservers" as opposed to "water sourcers".

Water conservers are plants that store copious amounts of water in their fleshy stems and leaves. Cacti are the poster children for "water conservers". They absorb water when available, and conserve it by closing their leaf pores during the day, by having a waxy cuticle over their leaves and stems, and by having relatively little surface area. Water sourcers, on the other hand, are plants that have extensive and deep root systems that go deep into the earth in search of water. Good examples of "water sourcers" are prairie plants such as little bluestem, purple coneflower, and prairie dock.

Recommended Plants

The LiveRoof system is typically vegetated with a palette of deciduous, semievergreen and evergreen "base mix"
and "accent plants" that are exceptional "water conservers". These are succulent, water-holding plants like Sedums, Alliums, Sempervivums, Euphorbias, Delospermas, and other species. The best LiveRoof plants both store water and have a special type of metabolism called Crassulacean Acid Metabolism, CAM for short. CAM plants are unique in that under drought conditions their stomates (leaf pores) are open at night rather than during the day (as is the case with most plants). CAM plants exchange gasses (oxygen and carbon dioxide) in the dark when it is cooler and less windy and therefore conserve water. And, CAM plants are up to ten times more efficient with water conservation than non-CAM plants.

Can Native Plants Be Used?

While it is popular to say that native plants are better adapted because they evolved here,

this notion is not necessarily true. A plant's toughness or suitability, is dependent upon genetics and ecological and environmental adaptation (evolving with time and exposure). There is nothing magical about latitude and longitude as there may be similar or more demanding environmental conditions on the other side of the globe. In reality some native plants are tough, some aren't, and a few will grow in an "extensive" green roof without frequent irrigation. The list, however, is quite short as the native ecosystem parallel would be a giant rock covered in 2 to 4 inches of gravelly soil with loads of reflected light from bordering rocks. Such "real world" parallels are few and far between.

Even though there is not a long list of native plants for use in extensive green roofs (unless one plans to frequently irrigate), there are a few to choose from. Such species as Sedum ternatum (white flowered sedum, a shade lover), Opuntia humifusa (prickly pear cactus), and Allium cernuum (nodding onion) are such plants. Of course, with regular and frequent irrigation, many others can be sustained, and plants that fall into this category include purple coneflower (Echinacea pallida) and little bluestem (Schizachyrium scoparium). These plants are very drought resistant in conventional landscape settings, because they are great "water sourcers". On a rooftop with 4 inches of soil, however, they won't survive for long unless regularly irrigated. Such plants are better suited to the LiveRoof Deep system.

The bottom line: LiveRoof growers are interested in using plants that will be successful, regardless of regional nativeness. Rest assured, LiveRoof growers only use plants native to this planet.

Wind Pressure

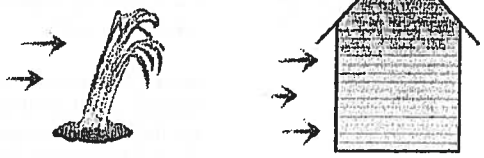
As with any roof, high winds can pose a threat to the security of green roofs, and care must be taken to properly design and engineer the green roof so that it retains its integrity during high winds. To do this, consideration of wind pressure and associated variables, such as the building's geographic location, surrounding terrain, shape, slope, height, building openings, parapet design, and other features is essential.

At the tip of the iceberg, of wind pressure, one must consider the typical high wind speeds for that region. Consulting ASCE 7.95 Figure 6-1 Basic Wind Speed, or Factory Mutual Global Property Loss Prevention Data Sheet 1-28 is a good first step. In addition, the engineer must consider the surrounding terrain; for example, is the building situated along water, mountains, open field, surrounded by tall trees or taller buildings?

Of course the building design itself is very important. Low rise buildings (generally regarded as 60 feet and lower) are less affected than high rise buildings (60 feet and taller) which in addition to direct (positive) wind pressure are more greatly affected by negative wind pressure, often referred to as uplift or suction.

Positive Wind Pressure

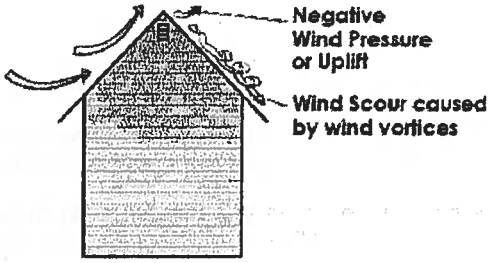
Positive Wind Pressure is the force exerted by the wind as it strikes an object, or building. Positive Wind Pressure is evident when a tree (or other object) moves or bends over in a strong wind.



LiveRoof modules, when populated with a base mixture of flexible-stemmed hardy sedums (the backbone of the LiveRoof product line) were wind tested on 1/25/08 with wind speeds exceeding 110 MPH. In this test, the LiveRoof planting (4' x 5') was surrounded with RoofEdge edging and first exposed to 10 minutes of wind at 95 MPH, followed by 1 hour and 50 minutes at 110+ MPH. The wind was impinged directly upon the surface of the LiveRoof planting as would be the case when testing other roof coverings. Remarkably, at the end of the test period, there was no loss of growing medium and all plants remained well rooted and intact. Throughout the test, the plants simply arched over, held in place by their root systems. This test demonstrated the value of full vegetative cover as a means of stabilizing the green roof system.

Negative Wind Pressure, Uplift

Negative Wind Pressure is what causes airplanes to fly, and it's what causes roofs to want to fly. Negative wind pressure occurs when wind passes over an object that causes the wind to redirect and accelerate. This in turn creates a pressure differential and the pressure differential can be substantial.



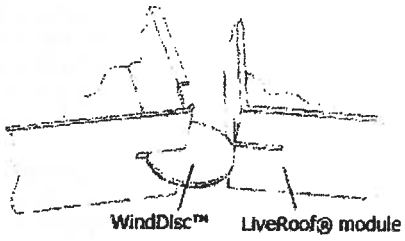
In the case of roofs, wind accelerates as it passes over the roof edge or parapet, causing a pressure differential and lifting force, uplift, that is exerted upon the rooftop. Redirected winds of this nature tend to whirl and swirl, often in cone shaped vortices which can aggressively scour roof surfaces and components. Such forces are typically greatest in the corners of the roof, secondarily along the parapet walls, and to a lesser degree in the "field" or center part of the roof. Uplift forces vary with the building shape and height, parapet shape and height, overall exposure, size of openings, etc.

Wind Uplift Test Performance and WindDisc™

During 2012, LiveRoof LLC worked with a team of code officials and engineers from the US and Canada to become the first green roof system in North America to undergo full scale dynamic wind uplift testing, giving us empirical data related to how the LiveRoof system performs against uplift, with and without LiveRoof's patent-pending WindDisc™ technology.

Suffice it to say, during laboratory testing, the LiveRoof system with subterranean overlapping edges and full vegetation performed admirably and its performance was further enhanced with WindDisc technology.

The WindDisc is a simple way to secure LiveRoof modules together to improve wind uplift resistance. At uplift pressures exceeding 200 psf, the modules remained connnected across the green roof surface with the WindDisc module connectors in place.



The WindDisc technology allows for any size LiveRoof modules or RoofStone pavers to connect together across a green roof installation. Please contact us for more information.

Wind Design Standards

In 2010 the American National Standards Institute (ANSI) accepted RP14 Wind Design Standard for Vegetative Roofing Systems as an American National Standard. This document provides design and installation recommendations to mitigate the risk of wind uplift on green roofs in high wind areas. LiveRoof modules are fully vegetated at the time of installation and have subterranean overlapping lips, which allows them to be sheltered from direct wind exposure. The LiveRoof Lite System is 2.5" deep and has a dry weight of approximately 10 lbs per sq ft, and thus meets the definition of #4 Ballast (3.13.1). The deeper Standard (4.25"), Deep (6.25"), Maxx 8" and systems meet the definition of both #4 Ballast and #2 Ballast (3.13.2).

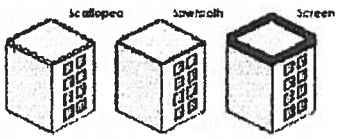
On our website, we mention these considerations as an impetus to diligent design and engineering, but do not purport to have specific knowledge of engineering principles. Such expertise and accompanying liability is the domain of qualified engineers. We will continue to pioneer new research to continue to provide improved support services to engineering professionals. For now we offer the following list of considerations to stimulate a diligent review of design and engineering considerations as they pertain to green roofs.

Parapet Design

Low rise buildings in areas of moderate exposure may present fewer challenges in regard to Positive or Negative wind forces. But, taller buildings may cause one to have to be more creative. Design strategies that moderate wind uplift forces and disrupt the formation of surface-scouring wind vortices may be employed in the overall green roof design.

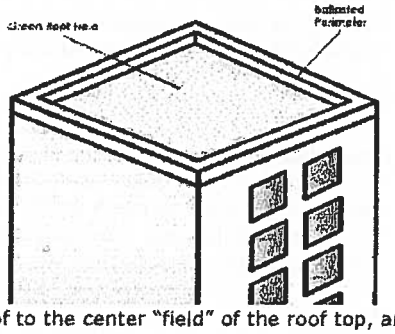
Regarding low rise buildings, a lower parapet design may avoid potential air turbulence and help to minimize uplift forces. And, for buildings containing only a single parapet, as is commonly used as a facade for aesthetic purpose, one should keep in mind that the parapet may dramatically increase the uplift pressures in the corner regions. Conversely, on high rise buildings (over 60 feet), higher parapet height can be an effective tool in moderating uplift forces. Studies on parapet height typically indicate that parapets over 3 feet tall can moderate uplift pressure in the corners of the roof on high rise buildings. Likewise, the use of a partial parapet with attached porous screen may be used to reduce uplift pressures and expand design options for taller buildings. And, parapets of different shapes, e.g. saw-tooth configuration, rounded vs. sharp edges, or the application of spoilers are sometimes used.

Keep in mind, that the taller the parapet, the more Positive Wind Pressure against the parapet itself, both windward and leeward sides.



Wind Challenged Applications

In very challenging applications an engineer may have to direct the architect to forego using the LiveRoof Lite system (about 9 to 10 lbs per sf when bone dry) in favor of the LiveRoof standard system (about 18 to 20 lbs per sf when bone dry). And, in the most wind challenged applications, an added means of securing the LiveRoof (either LiveRoof Lite or Standard) may be needed to safeguard the LiveRoof system. Accessory products for extreme uplift designs may include any or all of the following. **(A-C)**



A. Limiting the LiveRoof to the center "field" of the roof top, and using heavier ballast in the corners and along the parapet edges. Such ballasted perimeter design is referred to as a "vegetation free" zone. Vegetation free zones will vary with the parapet height and geometry.

B. Overlaying the LiveRoof with a mechanically fastened stainless steel netting such as CarlStahl's Decorcable, flexible stainless cable mesh, sales@decorcable.com, 800-444-6271 or G-Sky Netting.

C. Adhering the LiveRoof modules to a fully adhered rooftop using special two-sided adhesive tape.

Tall Buildings: How High is Too High?

Tall buildings present three substantial challenges for green roofs. The first is wind uplift. This is a physical phenomenon that presents certain design and engineering considerations, discussed in detail under the .

The second is wind scour. This is the physical displacement of soil and/or plants due to the force of the wind. The best defense against wind scour is full-vegetation, which LiveRoof provides. It is also important to remediate any "bare-patches" that might arise in the future. Bare patches can be caused by weed encroachment, nesting, birds, or physical damage.

The third challenge involves the plants and their ability to resist the wind and cold at high building elevations.

The answer to the question "how high up can green roof plant survive?" is not well understood, at least not at this time. Very tall buildings, for example over 20 stories tall, are subject to virtually constant wind. This in itself is not a problem for the plants, as most green roof plants hail form alpine environments where there is also a lot of wind.

The problem seems to be an issue of dehydration and wind chill, particularly in areas of persistently cold winter temperatures. In such cases, the soil will be frozen for prolonged periods of time, and therefore, the plants can not extract water from the soil to replace the moisture lost from wind desiccation. If this occurs for too long of a duration, the plants essentially become "freeze dried", and their tissue dies.

At the present time, the level of experience and bona fide research with this problem is not sufficient to be able to quantify the effect in such manner that makes it simple to properly

plan and design for tall building applications. No one can say "on the 35th floor in New York City, you can effectively grow these five species of plants". Therefore, at present we must rely upon anecdotal experiences, and upon common sense.

What we suggest is the following:

The issue will likely be more significant in Chicago than Atlanta: The tallest LiveRoof brand green roof, to date, in Chicago is at 28 stories. Installed in 2010, but it has not yet seen a winter. We have, however, installed a LiveRoof brand green roof on a 16th. story exposure during 2008, and it has persisted without a hint of plant damage during wintertime (note: the winter of 2008/9 was one of the coldest in recent history).

Deciduous plants: Plants that drop their leaves are likely better equipped to resist the rigors of constant winter chilling winds. This is because they present less surface area for chilling.

Irrigation is good: In areas where the winters tend to be dry, giving the plants periodic irrigation can help them to resist dehydration during cold spells.

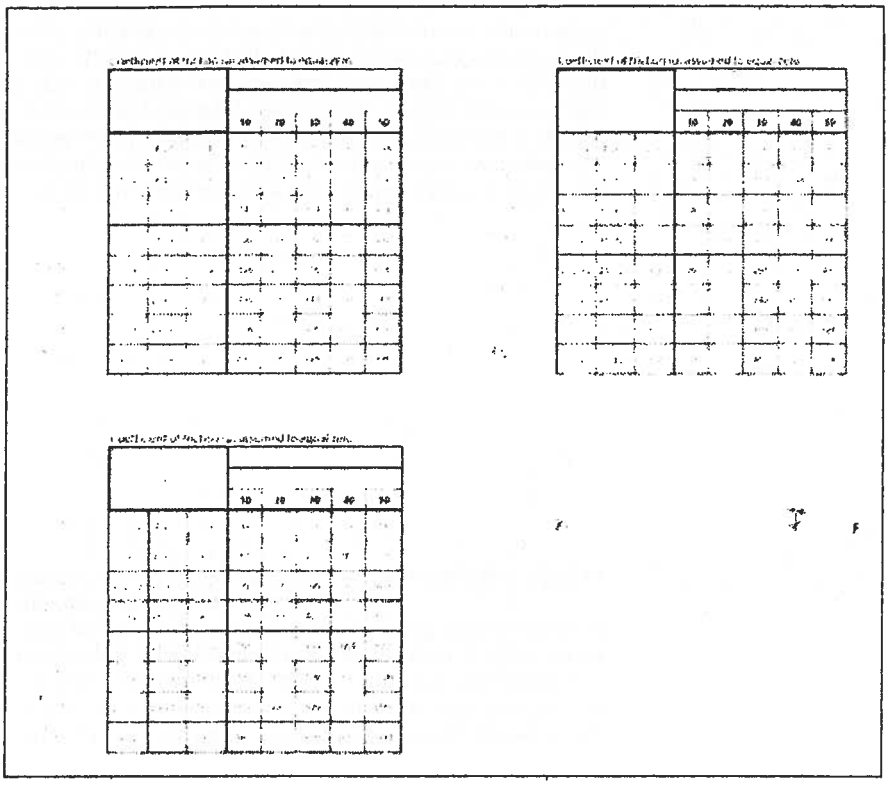
As we learn more about this issue, we will make that information available.

Downward Force Against Parapet For Sloping Applications

The combination of a green roof (unaffixed object), slope, and gravity imply the need to address physical containment and resistance to downward pressures exerted by the green roof against the parapet and mechanical fixtures of the roof especially in cold climate areas where ice crystals may form on the slip sheet/root barrier surface during winter. For this reason, LiveRoof recommends that the slope and size of the roof be assessed in regard to force that will be exerted against the parapet (or other mechanical features of the roof). For the convenience of engineers, LiveRoof provides force tables for use in designing each particular LiveRoof project. These tables assume "zero" friction and present a conservative model based upon the assumption of ice between the slip sheet membrane and the LiveRoof modules during the winter months. Obviously, this may not be appropriate for frost free zones, but one must realize that certain roofing membranes are coated in talc or other lubricants to prevent sticking. Others membranes may be slippery when wet. Therefore, even in frost free zones, one should assume a degree of downward force on sloping applications.
For long roofs and roofs with great slope, it may be appropriate to incorporate "stops" or buttresses in the design to prevent all of the load from being exerted against the parapet on the low side of the roof. In all cases, it is important to realize that the low side parapet must be built in such manner as to have the structural integrity to resist whatever forces exist given the design of the particular roof.

How Much Slope is Too Much?

Both of the main international green roof organizations, the German FLL and North America's Green Roofs for Healthy Cities agree that green roofs should not be applied to roofs with slope of greater than 40 degrees. This stems both from containment challenges but also from the extreme difficulty in managing soil moisture on a roof of such pitch. You may be familiar with the properties of a wet sponge, where it will hold so much water when laying on its side. But, after you prop it up on its end even more water runs out. Soil acts the same way and as the pitch of the roof increases, there is a greater tendency for the water to want to run out of the system. Green roofs above 2'/12' pitch are commonly dry at the top and moist at the bottom. And, while the segmental or baffled characteristic of LiveRoof may help to mitigate this phenomenon, pitched roofs will certainly require more irrigation than low sloped green roofs.



How Much Slope is Too Little?

While this question is seldom asked, it is important to design for adequate drainage. Most authorities state that a roof needs ¼"/12' slope to provide adequate drainage. Without this, water may accumulate and damage the health of your LiveRoof plants.

Level or Gently-Rolling?

Most LiveRoof installations simply follow the contour of the roof for a lovely, gently-rolling, meadowlike appearance. If a dead-level LiveRoof is required, it can be realized by applying a tapered closed cell foam to the roof above the waterproofing layer. If this is done, the closed cell foam must allow for adequate water drainage.

Job Site Safety

Remember, wind uplift should be managed during the entire installation process. High winds can come at any time and will not wait for the installation process to be completed. Be sure to cover materials with appropriate temporary ballast.

Retrofit Roofs

Retrofit Projects are exciting as they represent a tremendous upgrade to aesthetics and environmental quality. Of course, they bring their own particular challenges that need to be addressed from an architectural and engineering standpoint. Here are some of the main considerations for retrofit green roofs.

- Determination of the construction, condition, and load capacity of the pre-existing roof and suitability to accept a LiveRoof.
- Determination of the condition of, remaining warranty lifetime, and terms or warranty of the existing waterproofing system as it pertains to being retrofitted with the new LiveRoof.
- Compatibility of the existing waterproofing system with the proposed slip sheet membrane.
- All the same issues regarding positive and negative wind pressure, slope, and forces against the parapet as they relate to new construction also apply to retrofit roofs.

Fire/Spread of Flame

On 1/25/08, LiveRoof was tested to see how it performs when its surface is exposed to flame via a test method typically applied to other roof coverings. In this case, a Sedum-populated LiveRoof Standard modular system was installed on top of a plywood deck and

subjected to a direct flame for 10 minutes. Following 10 minutes, there was no ignition of the plywood deck and no spread of the flame via the plant material. While, the plants in the path of the flame were scorched and reduced to ash, they did not ignite and spread the flame. Neither did the LiveRoof soil, and the module itself remained intact.
Note: if the LiveRoof modules were populated with plants other than Sedums, which are succulent, the result may vary. For example, if dry grasses were planted in the system, one might expect them to burn and propagate the flame.

In 2010, the American National Standards Institute (ANSI) accepted as an American National Standard. This document provides design and installation recommendations to help eliminate the risk of fire on green roofs. A code change proposal has been submitted to the International Building Code to include this standard in the 2012 edition of the International Building Code. Depending on the plant selections, LiveRoof systems meet the requirements to qualify as generic fire-resistant "Succulent based systems" (4.1.1) or "Grass based systems" (4.1.2).

FM Approved

In July 2011, the LiveRoof® Hybrid Green Roof System became the first to be FM Approved according the FM Standard 4477. Developed by FM Approvals, LLC, is the approval standard for vegetative roof systems. It evaluates green roof performance related to fire, foot traffic resistance and water leakage. In addition to testing the LiveRoof system, FM Approvals examined LiveRoof's manufacturing facilities and audited its quality control procedures to verify that the company produces a consistently uniform and reliable product.

Recognized and respected worldwide, the certification process assures that products and services have been objectively tested and proven to conform to the highest property loss prevention engineering standards. Building owners and facility managers who rely on FM Approved products now have LiveRoof as a .

The approval is granted to the LiveRoof Standard and Deep Systems populated with succulent groundcovers. For specific information on Approval requirements and compatible membrane assemblies, view our .

To Irrigate or Not to Irrigate?

While irrigation may only be needed during protracted hot dry weather (to sustain the plants), there are other reasons to install an efficient means of irrigating one's green roof. Irrigation allows the green roof to be fully optimized. With the ability to irrigate during hot dry weather the rooftop can be turned into one big cooling unit and save money on air conditioning. Remember water liberates 8000 BTU of energy during evaporation (latent heat of evaporation), and pumping water is efficient and cheap, but running air conditioners is inefficient and expensive. The cooling effect derived by irrigating allows for the conservation of energy in comparison to the energy wasted on cooling by less efficient methods.

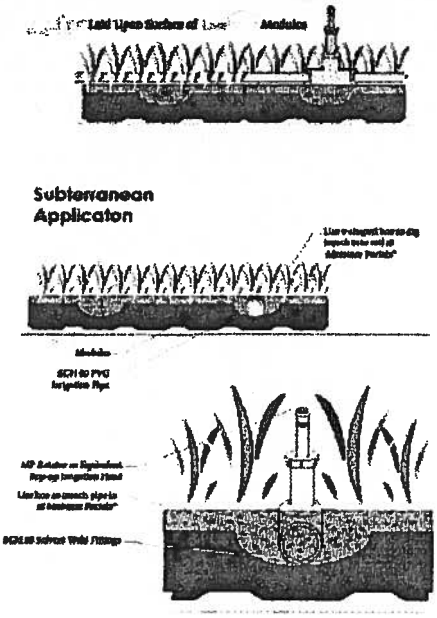
According to some authorities, and dependent upon the particular climate, during the cooling season the temperature in the room below an irrigated green roof may be reduced 16 to 27°F compared to a reduction of about 11-13°F for a non irrigated green roof. This difference is substantial and can mean considerable savings on air conditioning costs. Estimates of cost savings for air conditioning range from 25% to 50% for the floor under the green roof. Irrigating during hot dry weather allows for the optimization of the green

roof's cooling ability.

In rough figures, when an extensive irrigated green roof shows an average summertime temperature of 80 degrees, the same roof without irrigation will average about 100 degrees. Similarly, the membrane below the irrigated roof might fluctuate an average of only 7 or 8°F during a 24 hour period, while the same green roof without irrigation may fluctuate ± 20 degrees. Less fluctuation may mean less wear and tear via micro-tearing on membranes, and therefore potential extension of the lifetime of the waterproofing membranes.

Judicious irrigation also keeps the green roof plants fat, full and beautiful. This means better coverage, fewer weeds, less labor, and happier owners, occupants, and visitors. It also means lower maintenance costs and safeguards one's investment in the green roof.

Finally, judicious irrigation should not significantly impact stormwater management as irrigation typically occurs only during low rain/low runoff periods when the roof will dry out quickly from evapotranspiration.



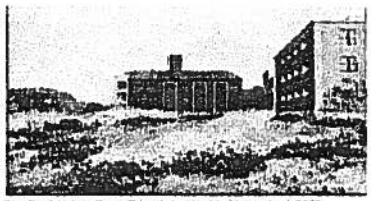
Benefits of Irrigation vs. No Irrigation

- Net energy savings
- Reduced temperature fluctuation (less wear on membrane)
- Less maintenance cost
- Plants will be optimally beautiful
- Avoid plant loss due to drought
- Greater owner satisfaction

What Will My LiveRoof Look Like In The Future?

All plants are unique, and are opportunistic in one way or another. LiveRoof plants are no exception, and practically speaking, some species tolerate heat better than others, some cold better than others, some dry conditions, and others moist conditions. By combining species of varying growth characteristics, we strive to design each LiveRoof plant assortment to perform optimally in all seasons.
Over time, depending upon the particular plant assortment, geographic site, climate and microclimate, the plant assortment will adapt and evolve. One species will increase its presence while another decreases its presence, from season to season, and from year to year. It is this evolutionary dance that helps to make each LiveRoof fresh and exciting now and in the future.

LiveRoof Installation - Grand Haven, Michigan - August 2007 (day of installation)



LiveRoof Installation - Grand Haven, Michigan - June 2008

BIM Components

LiveRoof® BIM Components are now available on Autodesk® Seek and LiveRoof.com for the LiveRoof® Standard, Lite and Deep Systems.