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Green, Living Wall Design Considerations

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Presented by: LiveWall, LLC
PO Box 533
Spring Lake, MI 49456 USA

Description: Provides an overview of living walls with a focus on vertical planter systems with integrated irrigation. Presented are discussions of the benefits of living walls, a comparison of system options, as well as design and specification considerations, including plant selection, growing media, lighting, and maintenance requirements.

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Purpose and Learning Objectives

Purpose: Provides an overview of living walls with a focus on vertical planter systems with integrated irrigation. Presented are discussions of the benefits of living walls, a comparison of system options, as well as design and specification considerations, including plant selection, growing media, lighting, and maintenance requirements.

Learning Objectives:

At the end of this program, participants will be able to:

- state the benefits (financial, aesthetic, health, and environmental) of living walls for indoor and outdoor environments
- define and compare the various types of living wall systems in terms of performance, cost, maintenance, etc.
- discuss the structural and design considerations, the components, and maintenance requirements of vertical planter systems with integrated irrigation, and
- explain light intensity and spectrum requirements for living wall systems.

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Benefits of a Living Wall

Introduction

What is a living wall?

Living wall systems are composed of pre-vegetated panels, “planted blankets or bags that are affixed to a structural wall or free-standing frame. These modules can be made of plastic, expanded polystyrene, synthetic fabric, clay, and concrete and support a greater diversity and density of plant species (e.g. a lush mixture of groundcovers, ferns, low shrubs, perennial flowers, and edible plants) than green facades,” (vines which climb or cascade into supporting structures).

Source: Green Roofs for Healthy Cities. “About Green Walls.” Greenroofs.org, 2014.
http://greenroofs.org/index.php/about/aboutgreenwalls
Accessed March 9, 2015.

Why Living Walls?

Planted living walls are intended to beautify the environment, but they are also excellent at reducing energy consumption, cooling their surroundings, creating habitat, and providing social benefits by invoking feelings of tranquility, respite, and inspiration.

And they are not limited to exterior applications: their use can extend to the interior of a building to help purify the air and create a peaceful, stress-relieving environment.

In this section of the course, we will review the financial, aesthetic, health, and environmental benefits of living walls in detail.

Financial Benefits: Marketing & Productivity

When used for signage, a planted living wall is a great way to expand a brand.

A living wall tells customers, residents, employees, or neighbors that you care about your health, your community, and the ecosystem.

Research by Alex Haslam of the University of Queensland found that an office enriched with plants makes staff happier and boosts productivity by 15%.

This two-story living wall greets staff and customers as they enter the Westland Real Estate office on Willow Street in Long Beach, CA.

Financial Benefits: Energy Savings

Vertical gardens save energy and conserve resources.

When used outdoors, the evapotranspirative effects of living wall plants and the growing medium can reduce HVAC costs during hot weather.

A study headed by Dr. Tilley of University of Maryland estimated air conditioning energy savings of up to 35–65% when a building is vegetated on the east, west, and south walls simultaneously.

Indoors, living walls bring natural humidity and a reduction of volatile organic compounds (VOCs), which are common airborne pollutants.

Financial Benefits: Food Production

The potential of living walls to grow herbs and vegetables expands their usefulness into the arena of urban farming. A “food wall” installation can be applied on any scale, ranging from personal to commercial.

When installed at restaurants, culinary schools, and institutions, vertical gardens can reduce costs and provide nutritious herbs and vegetables from a surface that previously performed no such function.

Certain systems yield up to one ounce per square foot per week of fresh herbs and greens and allow for a variety of vegetables and strawberries to be grown and harvested.

Financial Benefits: Zoning Ordinances

Planted living wall systems may qualify for credits associated with green/open space in many municipal zoning ordinances, often equating to time and money savings in the zoning process or financial rewards from tax credits and other incentives.

Depending on the system design and site specifics, green wall systems typically contribute toward several credits within LEED 2009 and LEED v4.

This new bus stop displaced a landscaped bed in an urban area. Without ground-level space available, the designers were able to replace the greenery with a living wall that naturally helps to keep riders cool as they wait.

Aesthetic Benefits: Artistic Expression

Let's move on to discuss the aesthetic benefits of living walls.

Planted living walls are an attractive, organic alternative to traditional two-dimensional architectural siding treatments. They expand the usefulness of buildings and create three-dimensional siding systems with unlimited options for color and texture.

Living walls can be planted monochromatically, randomly, and in geometric patterns. Colors, textures, and scents change throughout the year, providing a variety of aesthetics. Certain systems allow for ongoing artistic expression as they allow easy replanting, rearranging, and redesign for a fresh, evolving living canvas painted with a broad palette of plants.

This living wall at the B.O.B. in Grand Rapids, MI buffers the noise and odors of the facility's necessary but unsightly dumpsters and HVAC units.

Health Benefits: Stress Reduction

The next topic for discussion is the contributions to physical and mental health that living walls provide.

Planted living walls can significantly reduce ambient noise and create a more beautiful, relaxing, and inspirational environment. This exposure to nature has been shown to reduce stress and allergies and contribute to mental and physical health.

Health Benefits: Stress Reduction

Plants have been proven to positively affect mood, perception, feelings, and creativity.

Colors such as red, orange, and yellow evoke feelings of warmth and comfort.

A palette of pastels helps create a sense of calm. Blue, purple, and green are known to be both calming and refreshing.

Conversely, sweeps of strongly contrasting colors stimulate energy and feelings of excitement.

Health Benefits: Promotes Healing

Patients who physically interact with plants experience a significantly reduced recovery time after medical procedures.

Mobile healing gardens are possible, which may be easily moved to allow greater patient access to therapeutic gardening exercises.

This living wall is part of an enclosed horticultural therapeutic conservatory which is available to patients of the Einstein Health Network's MossRehab center in Elkins Park, PA.

Health Benefits: Fresh Food

Organic herbs and vegetables can be produced in certain living wall systems, and many people now consider it important to know where and how their food is grown. Because of this, living walls are becoming popular with restaurants, culinary schools, institutions, and the homes of people who are serious about nutrition, health, and healthy cooking.

Health Benefits: Social

Living walls, as part of green communities, increase sense of pride and place, levels of trust, and civic participation.

Similarly, green communities see less violence, aggression, vandalism, and littering, for overall improved social health.

Health Benefits: Education

In terms of green schools, living walls can provide educational opportunities and enhance student performance, as well as mental and physical health. In fact, a recent study of Massachusetts third-graders demonstrated that student exposure to nature has been correlated with higher academic performance in math and English. Exposure to nature also eases symptoms of ADHD.

Students who are engaged with the planting and maintenance of living walls learn about the vital role of plants in air quality, climate control, and food production. Furthermore, children who are involved in the process of growing their own food are more likely to have healthier diets.

Environmental Benefits: Cooler, Cleaner Air

Now we move on to discuss the environmental benefits of living wall systems.

Living walls cool and quiet urban environments, provide natural habitat, and help reduce urban heat islands.

The urban heat island effect refers to the temperature difference between urban areas and their rural surroundings. This temperature differential causes air currents and dust, and even contributes to violent weather events within urban settings.

Green walls help cool the air, slow air movement, and act as a substrate for pollution to settle out and detoxify.

Environmental Benefits: Noise Reduction

Plants, soil, trapped air, and moisture in the soil are great acoustic insulators.

Studies have shown that green walls can reduce ambient noise by up to 40 decibels, an important benefit to those who work or live close to noisy streets, highways, and airports. Because the decibel scale is logarithmic, every 10-decibel reduction equals a tenfold decrease in intensity.

Ambient noise levels on a busy street typically average 75 decibels. The design for a quiet office may target 60 decibels, a quiet urban neighborhood may average 40 decibels at night, and a quiet library may seek to operate below 40 decibels. For building professionals, it is easy to see how additional tranquility can contribute to a building plan.

Methods of Greening Walls

Methods of Greening Walls: Introduction

There are numerous commercial living wall options on the market.

Some systems are hydroponic and anchor the plants into a soil-less substrate, such as rock wool or coconut coir with water circulated throughout the system.

Other systems are soil-based, and their design varies greatly in respect to the plant orientation, soil containment, water delivery, pricing, and performance.

This section of the course begins with a discussion of the considerations for selecting a living wall system, followed by a review of the various system options.

Selection Considerations

When selecting a living wall system, designers should evaluate the following system features.

- **Plant Health**: Does the system have a proven track record for growing healthy plants? How long will they last?
- **Instant Maturity**: Is this an option?
- **Flexibility**: Which plants can be grown in the system?
- **Year-Round Aesthetic**: What does the system look like during dormancy?
- **Aeration**: Does the system allow for good air circulation behind the green wall to prevent mold and mildew?
- **Installation**: How long does it take to install? Are shop drawings furnished?
- **Maintenance**: What are expected annual maintenance costs?

Selection Considerations

Some living wall systems (e.g., hydroponic, soil-based slot/cage systems) orient the plants to grow sideways. It is the opinion of some in the business that horizontal plant orientation can stress the plant and, in turn, affect its health and longevity. The exception may be plants that are adapted to growing on the sides of cliffs or trees (epiphytes).

Hydroponic Systems

The first living wall type for review is a hydroponic system, developed by Patrick Blanc, a botanist from France. Note: Other companies now manufacture and sell similar systems.

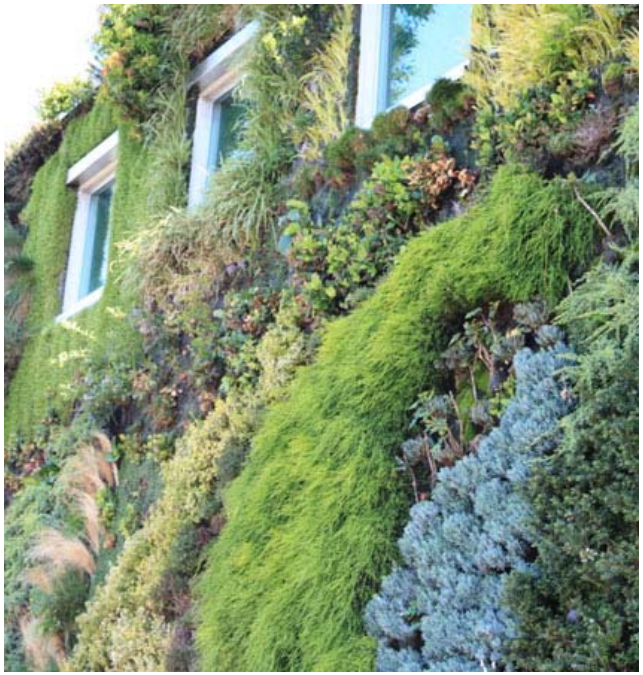
Hydroponic living walls are composed of a frame which encloses a fibrous material to conduct a nutrient solution and for the roots to adhere to.

To sustain the plants, hydroponic systems circulate water and nutrients through the medium that the roots are mounted into.

Hydroponic Systems

Advantages:

- Unlimited artistic expression (smaller planter units can yield more detailed designs)



Disadvantages:

- Expensive, $250–$400+ per square foot
- Horizontal system (plants are forced to grow sideways—unnatural orientation for most plants)
- Require regular maintenance and pruning
- Often too wet—lichens and mosses can take over
- Challenging to maintain, especially in cold climates
- Difficult to replant
- Must be continually watered or the plants will die
- This type of system requires a continuous supply of water, and the irrigation delivery system can create an opportunity for pathogens to be recirculated.

Soil-Based: Slot/Cage Systems

Soil-based living walls are available in two types of systems:

- slot/cage systems (horizontal plants), and
- planter systems (vertical plants).

Slot systems are made of metal or plastic and have mail slot-like compartments or cavities which are used to contain the soil and plants.

Some systems are “caged,” whereby they include a plastic or metal cover which helps to hold the soil in place.

These systems are typically pre-grown on their sides at a nursery, and the plants are turned sideways when the panels are installed on the building wall.

Soil-Based: Slot/Cage Systems

Advantages:

- Can be pre-vegetated
- Relatively easy to transport
- Cost less than hydroponic systems, approximately $100–200/square foot

Disadvantages:

- Horizontal system (unnatural orientation—plants are forced to grow sideways)
- Some systems are prone to soil erosion
- Limited plant options
- Difficult to replant
- Expensive ongoing maintenance

Soil-Based: Slot/Cage Systems

Disadvantages, cont'd:

Many of the slot/cage systems have metal or black plastic containers which may be hidden when the systems are first installed and if they are well maintained. However, in the winter when the plants are dormant, the containers are more exposed, compromising the aesthetics of the living wall.

Winter Aesthetic – Cage System

Soil-Based: Slot/Cage Systems

Drip Irrigation System - Some soil-based systems include a drip irrigation system which waters panels through a column of soil. Water is applied heavily at the top in order to saturate the bottom. Overwatering can cause the nutrients to leach from the top, and some walls watered in this manner retain too much water at the bottom, which can lead to fungal and disease infections.

Self-Watering System - Some planters are “self-watering” in which the water is held in a reservoir below a pot or planter, and the roots wick it up as needed. These systems can lead to a build-up of salts in the soil. If the roots actually sit in the water, the roots can rot. With some systems, the water sits in the reservoir and can become stagnant.

Spring Aesthetic – Poorly Performing “Mail Slot” System

Soil-Based: Vertical Planter Systems

Now we'll introduce the second type of soil-based living walls: vertical planter systems.

For the purposes of this course, we will be focusing on vertical planter systems that feature integrated irrigation. The irrigation system is different from the methods described on the previous slide, as water is delivered in a natural manner (from above, like rain), described in detail further along in the presentation.

Vertical planter systems allow the plants to grow upward from the top of the soil and the roots to grow downward as they do in nature. The vegetation is housed in planters seated in a metal framework attached to the wall.

Stems grow up, roots grow down, as nature intended.

Soil-Based: Vertical Planter Systems

Advantages:

- Can be pre-vegetated
- Plants grow vertically, natural orientation
- Relatively less expensive; systems cost approximately $80–$120/square foot installed and planted
- Attractive even during the dormant season
- Easy to install, water, fertilize, and maintain
- Unrestricted design creativity
- No soil erosion
- Grows a broad range of plants

Disadvantages:

- Large planter/pixel size compared to some systems

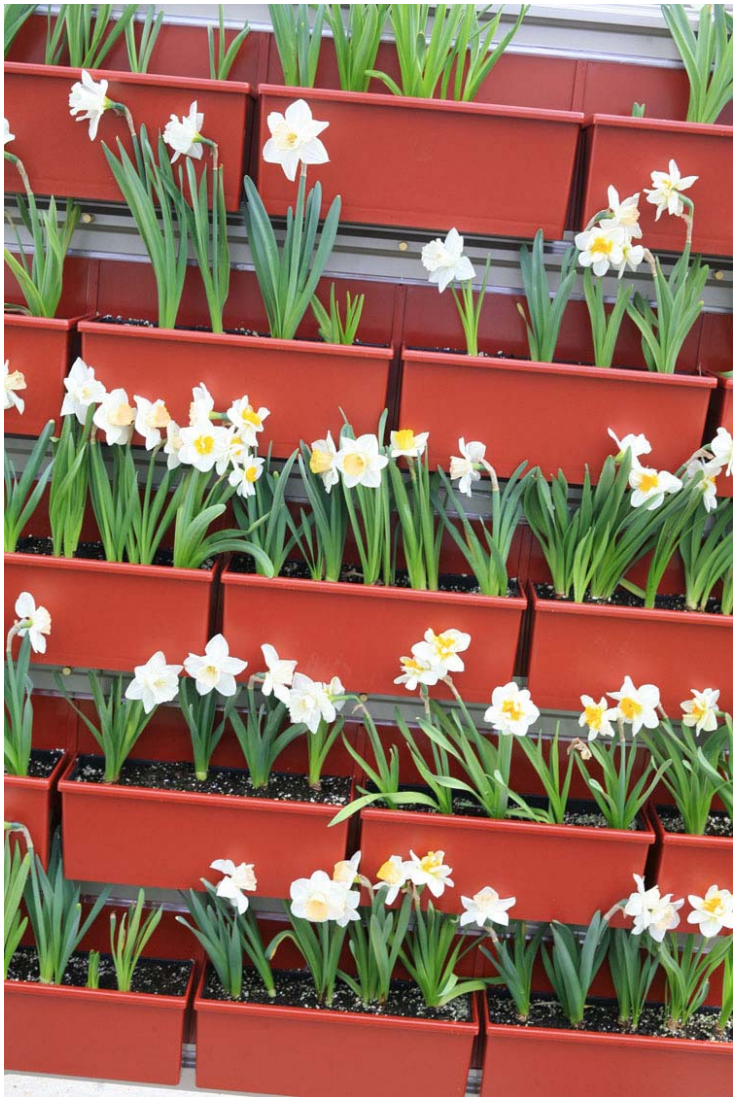
Vertical Planter Systems: Components

Components: Introduction

Available in the market are vertical planter systems that are constructed using a series of anodized aluminum rails and high-impact, UV-resistant, architectural moldings.

These systems feature integrated irrigation in which flood nozzles spray water onto each planter for rain-like watering.

Typically, these types of systems weigh from 10–15 lbs/square foot when fully grown and watered, making them suitable for most indoor and outdoor wall applications.



Vertical Furring Tracks

For outdoor applications, vertical furring tracks are used to attach the system to the building.

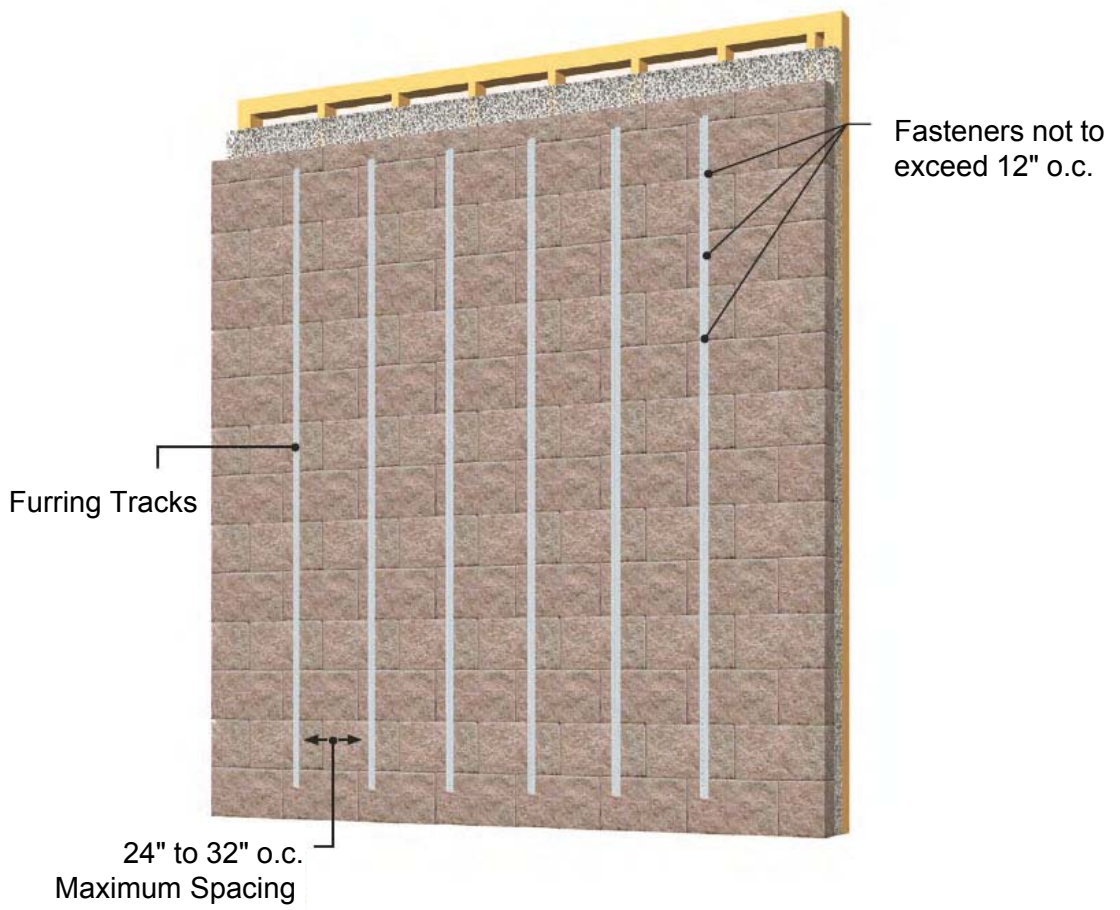
The tracks provide solid anchoring and ample space for any moisture to escape.

Installing the Furring Tracks

It is important to ensure that the furring tracks are set vertically, plumb, and correctly spaced no more than 32 inches on center for indoor applications and 24 inches on center for outdoor applications.

Align, then drive the top and bottom anchors, followed by all other anchors.

Provide a minimum of one anchor per 12 vertical inches to a solid, strong anchor point.



Hollow/Slotted Rails

After installing the furring strips, the hollow/slotted rails are attached to the furring tracks.

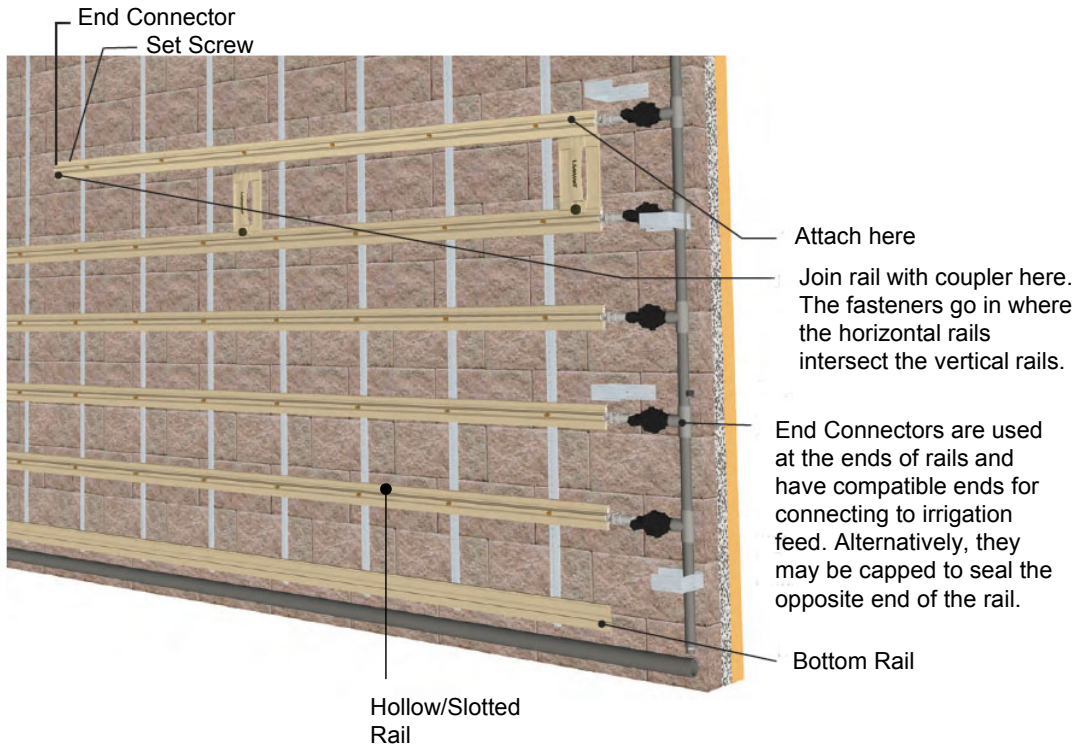
The hollow/slotted rails serve to both secure the wall planters and to supply the irrigation water.

Self-tapping screws are used at every point where the furring strips and hollow/slotted rails interface.

Irrigation Infrastructure

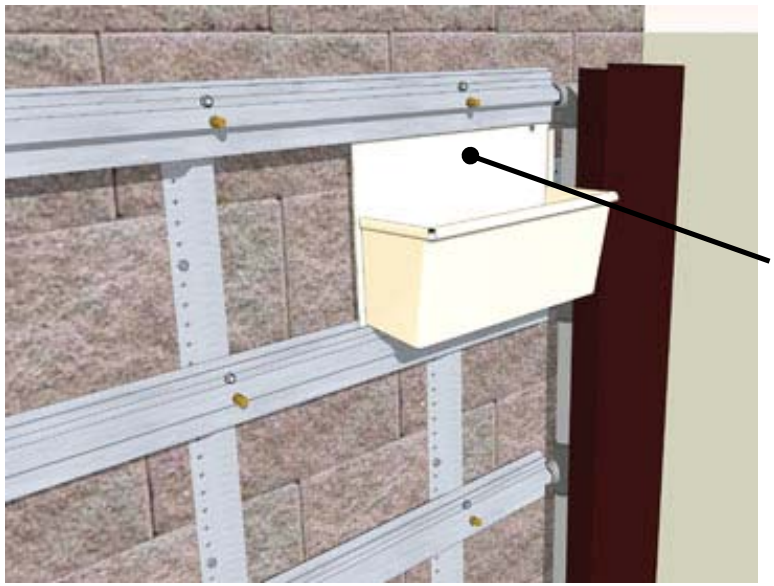
This photo demonstrates how the hollow/slotted rails serve as irrigation conduits.

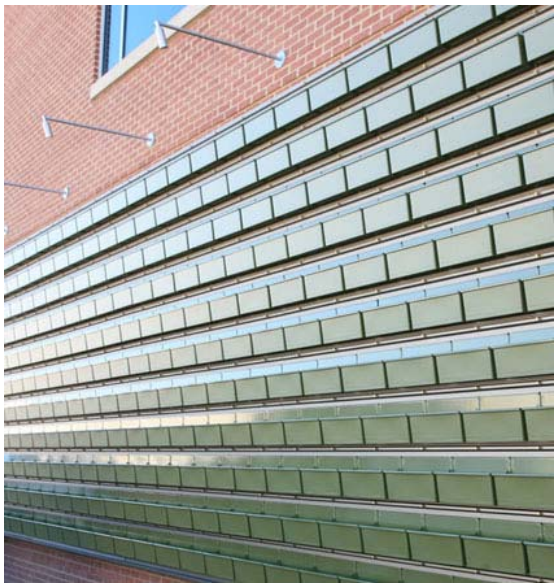
The irrigation infrastructure and chase brackets are installed after all of the horizontal hollow/slotted rails are installed. A common trade name for these rails is "RainRail®."



Wall Planter Modules

The wall planter modules are then installed into the hollow/slotted rails and secured with set screws. To complement the aesthetics of the building, the wall planter modules are available in a variety of sizes and colors.





Wall Planter Modules

The wall planter modules allow generous soil volume to provide ample room for the plants' roots to grow.

Wall Planter Modules

The wall planters are designed to be attractive when empty or during the dormant season. If annuals are used, the removable planter inserts make it easy to swap plantings for fall/winter color.

Wall Planter Inserts

Removable wall planter inserts allow the plants to be pre-grown in a nursery and delivered in a mature condition. The wall planter inserts conveniently drop into the wall planter modules and can be quickly and easily replaced and rearranged to provide flexible design solutions.

Wall Planter Inserts

The removable wall planter inserts make reinventing the wall seasonally very simple and affordable. The plants in the wall at the left were changed in just eight man hours for an entirely new fall design (on the right).

Irrigation: Outdoor Applications

With this type of living wall system, irrigation water is pumped through the hollow anodized aluminum rail, so the delivery system is durable and will withstand the elements.

The irrigation system needs to be connected to a suitable piping conduit consisting of header pipe and fittings, valves, a debris filter, irrigation controller, and fitting for annual “blow out” to clear piping conduit of water before freezing temperatures.

The flood nozzles spray water onto each planter in a natural manner, simulating rainfall. The water cools the soil and foliage and removes dust and dirt. The design of the system allows the planters to drain, negating the possibility of holding stagnant water.

Irrigation: Outdoor Applications

For outdoor applications, the living wall will need to be supplied with sufficient water pressure and volume at each valve.

When water is pushed upward, it loses pressure for every foot of distance it is lifted. Therefore, tall applications may require a booster pump.

Simple booster pumps, like these, will provide sufficient pressure boost for most taller walls. For high-rise installations, consult the living wall system manufacturer for support with booster pump selection.

Irrigation: Outdoor Applications

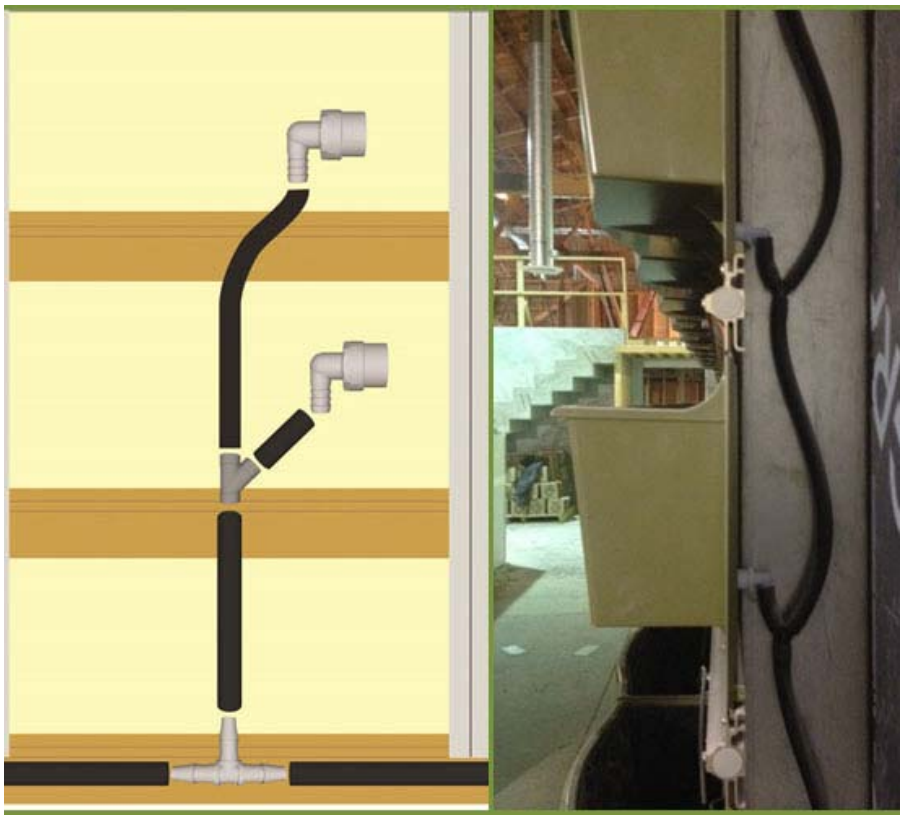
Day Planted

2 Weeks After Planting

2 Months After Planting

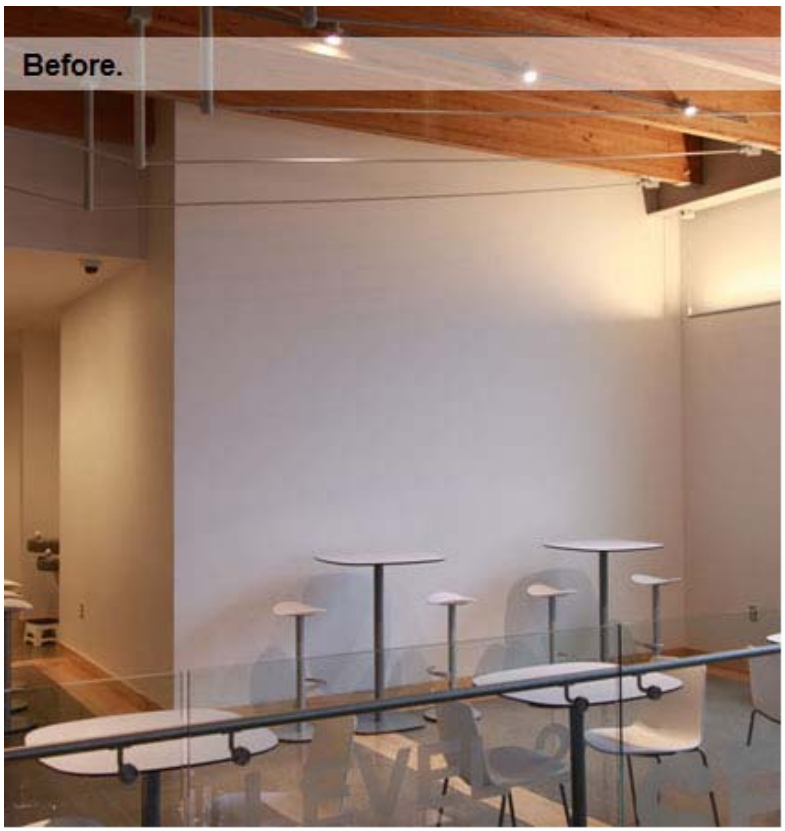
Irrigation: Indoor Applications

Indoors, water containment is a priority when designing living walls. Available in the market are indoor vertical wall planter systems that utilize drip irrigation stakes in each planter and feature a rear drain conduit for water containment to capture all water runoff.



Irrigation: Indoor Applications

Pictured below are before and after shots of an indoor living wall application using an integrated irrigation system.



Structural Considerations

Structural Considerations: Introduction

In this next section, we discuss the structural considerations that are necessary to facilitate a successful living wall installation, including:

- wind pressure
- air flow, and
- fire resistance.

To begin, quality vertical planter systems can be placed as high as your building infrastructure, plumbing, and ability to access it for maintenance will allow.

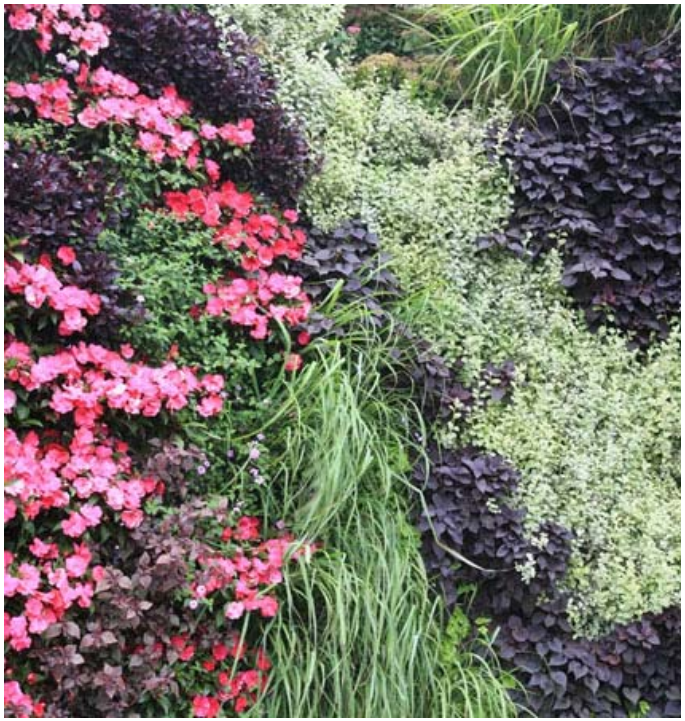
The oldest building in Southern California to achieve LEED® Platinum certification, the PacMutual campus in downtown Los Angeles, is also home to the city's tallest green wall (80 feet).
Here, the system is being installed.

Wind Pressure

High wind can pose a threat to the security of an outdoor living wall; therefore, a review of wind pressure and associated variables (i.e., geographic location, surrounding terrain, slope, etc.) is essential to protect the integrity of the installation.

A structural engineer must consider the natural forces on the building site as these factors can create a channeling force to intensify wind pressure against a structure.

Naturally, the building design itself is critical. Low-rise buildings (typically 60 feet or lower) are less affected by a given wind load than buildings that exceed 60 feet. These taller buildings may experience substantial uplift forces in addition to direct/positive wind pressure.

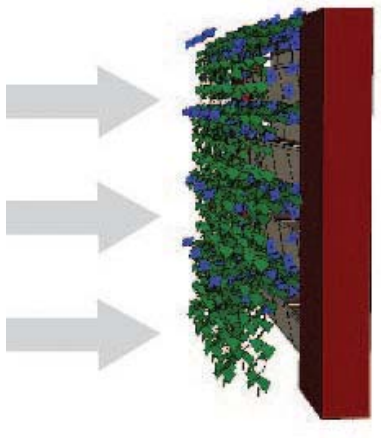


Wind Pressure

Wind accelerates as it passes over a wall, causing a pressure differential and uplift that is exerted on any living wall design.

Redirected winds of this nature tend to whirl and swirl, and such forces are typically greatest at the edges of the wall but vary with building shape and height, overall exposure, size of openings, and other local factors.

So how much uplift force can a vertical garden tolerate? The weight, surface area of the vegetation and porosity of the soil are variable; therefore, it is recommended to consult with the living wall manufacturer to discuss the wind lateral load conditions for your building site.



Positive Wind Pressure

Negative Wind Pressure (Uplift)

Air Flow

Vertical planter systems with integrated irrigation are designed to fasten to the building like many other siding systems. The installation method must allow sufficient room for air flow, evaporation, and escape of condensation behind the wall planter modules in order to prevent mold or mildew problems. Note that the exterior wall design and means of fastening a vertical planter system to the wall system must comply with local codes, and is the responsibility of the local architect and/or structural engineer and installation contractor.

An important component to any vegetated wall design is to recognize that moisture from the inside of the building often migrates outward through the walls, and for this reason, the building should not be wrapped in rubber or plastic, but with a breathable weather-resistant barrier, such as Tyvek.

Fire Resistance

Vertical gardens are facade systems and, as such, are not typically designed to be fire resistant.

Fire resistance varies widely depending on the system used. In most systems, the soil is relatively nonflammable, and the plant flammability varies by species.

For example, if fleshy succulent plants are used, they will help deter fire, but if grasses are used, they could pose a fire hazard if allowed to dry out.

Proper maintenance should keep the living wall moist, helping to reduce the danger of plant fires.

Design Considerations

Design Considerations: Introduction

Presented in this section of the course is a review of the following design considerations related to living walls.

- Plant Selection
- Soil Selection
- Light Intensity
- Light Spectrum
- Types of Light

Plant Selection

Depending on the system design, designers may choose from a broad variety of plant types.

Annual Plants: Last one season then die, but yield tremendous ongoing color display.

Perennial Plants: Last indefinitely—every three to five years will need to be divided to prevent overcrowded root systems.

Vegetables and Small Fruits: Food bearing plants, like beans, peppers, peas, carrots, spinach, and strawberries.

Succulents: Fleshy leaved perennials that are unique in that they don't typically become root bound and therefore can potentially last for decades without having to be replaced.

Herbs: Culinary and seasoning plants that often last one season in cold climates and live for several years in warmer climates.

Vines: Plants that trail downward and/or climb upward.

Tropical Plants: Used for indoor and outdoor applications in tropical climates.

Selecting Perennials in Cold Climates

For cold climates, perennial plants in wall planters need to have extreme root hardiness, as the roots are less insulated than if the same plants were growing in the ground.

There is no hard and fast rule for this—however, a starting point is to choose plants that are at least two hardiness zones more cold hardy than the local climate. This alone is not a guarantee as plants vary in their acceptance to overwintering “above ground.”

It is recommended that you consult with the living wall system provider for plant lists.

Selecting Perennials in Hot Climates

In hot climates, summer heat tolerance is the key challenge to overcome in selecting perennial plants.

It is best to work with the living wall system manufacturer to select plants that can withstand extreme heat.

Specify that the plants are fully mature upon installation so that they may shade the planter boxes and help shield the roots and soil from the sun.

Plant Selection and Design

Even the best living wall systems can be undermined by poor plant selection.

Plants must be selected based upon site-specific conditions, and the wall should be placed and designed in accord with the owner's intent.

Designers should contact the living wall system manufacturer for plant pairing and selection support.

Soil Selection

The type of growing medium to use in a soil-based living wall depends upon the plant selection.

- **Annuals and vegetables** require an organically-rich, lightweight potting soil. Specify a lightweight mix formulated with peat or coconut coir and a lightweight mineral aggregate, such as perlite, to ensure proper drainage.

- **Perennials** are expected to last three to five years in a container before they become root bound and in need of dividing; therefore, it is important to specify a soil that can last for a relatively long period of time before decomposing. Such mixes may contain composted pine bark, peat, and a long-lasting porous mineral component, such as perlite.

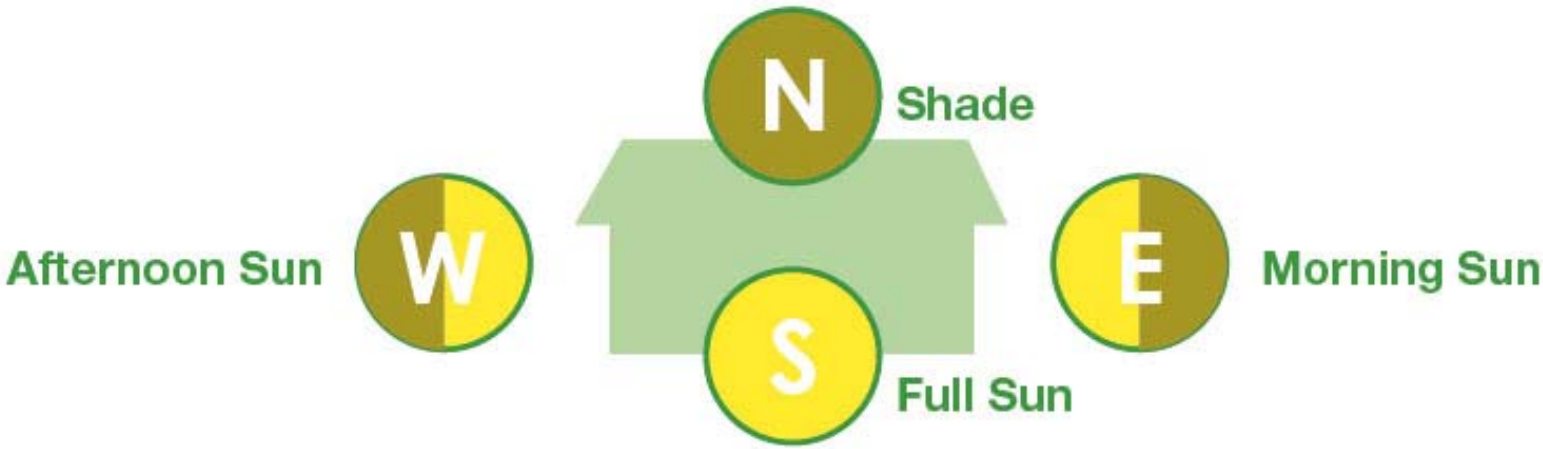
Soil Selection

- **Tropical plants and interior plants** may last for many years (like perennials) and thus a similarly formulated soil would be appropriate.

- **Sedums and succulents** tend to have sparse roots and may never become root bound. As a result, they have the potential to last for decades. If the intent is to grow for a few years, specify a mix as specified for perennials. If the desire is to maintain them long-term, specify a mineral-rich soil which will maintain its volume over time, similar to a green roof soil.

Light Intensity: Outdoor Applications

Lighting is critical to the success of a living wall. Before selecting plants, indicate the light intensity based upon the amount of natural light that the wall will receive.



In the Northern hemisphere, south-facing walls will be sunny, assuming they are not blocked by tall trees or neighboring buildings. East- and west-facing walls will be partially sunny/shady, and north-facing walls will be shady. The combination of climate and light exposure will dictate which plants will work in your particular setting.

Light Intensity: Indoor Applications

In nearly every indoor application, supplemental lighting will be necessary to ensure the proper intensity and spectrum of plant growth. Most indoor plants will grow well with 12–15 hours of light per day. For optimum growth, it is recommended that the lighting for the living walls is set on a dedicated outlet which is programmed to run for approximately 14 hours per day. Most plants require both light and dark periods; therefore, programming the growing lights to run at night is not advisable.

Designers should specify fixtures, bulbs, and placement to ensure that the living wall is evenly lit and receives the full spectrum of lighting required to grow healthy plants.

How intense must light be to grow healthy living wall plants indoors? The required amount of light for indoor plants varies. Presented on the following slide are descriptions of the categories of lighting needs.

Light Intensity: Indoor Applications

- **Intense light** pertains to an indoor location within an atrium or sunroom with unshaded light throughout most of the day. This is almost equivalent to growing outdoors in full sun.

- **Bright light** pertains to an indoor location with direct light from a south or west exposure where the plants receive two or more hours of direct sun, but preferably not during the hottest part of the day. Artificial bright light is approximately equal to a four-tube florescent fixture in close proximity to the planting in the range of 400 to 600+ foot candles, for 12 to 15 hours per day.

- **Medium light** pertains to an indoor location with direct light for a couple of hours in the morning or afternoon (from east- or west-facing windows), or from a south-facing window if the location is several feet interior of south-facing windows. Artificial medium light is approximately equal to a two-tube florescent fixture, two or three feet from the foliage, in the range of 100 to 400 foot candles for 12 to 15 hours per day.

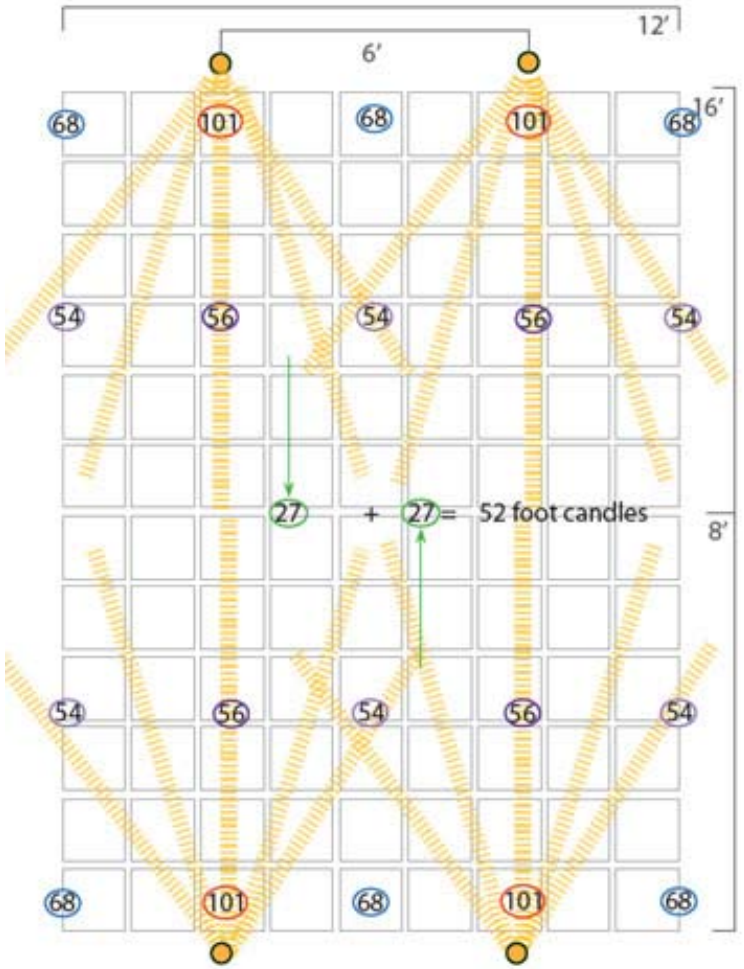
- **Low light** pertains to an indoor location that is not close to windows or supplemental lighting—typically a north or east exposure. Artificial low light is enough to read a newspaper, in the range of 25 to 100 foot candles for 12 to 15 hours per day.

Mapping Light: Indoor Applications

This is an example of the type of diagram that should accompany the specification to ensure adequate and even lighting.

The numbers circled indicate light measurement in foot candles generated by the fixtures and spacing.

Specifiers should call out the make and model and obtain light fixture specifications and/or .ies files from the light manufacturer(s).



The example to the left is lit by fixtures mounted on the ceiling 4' from the plant canopy (not the building wall), and from fixtures on the floor installed 4' from the plant canopy. The green wall is 12'W x 16'H, and wall is positioned approx. 1' above the floor and 1' below the ceiling.

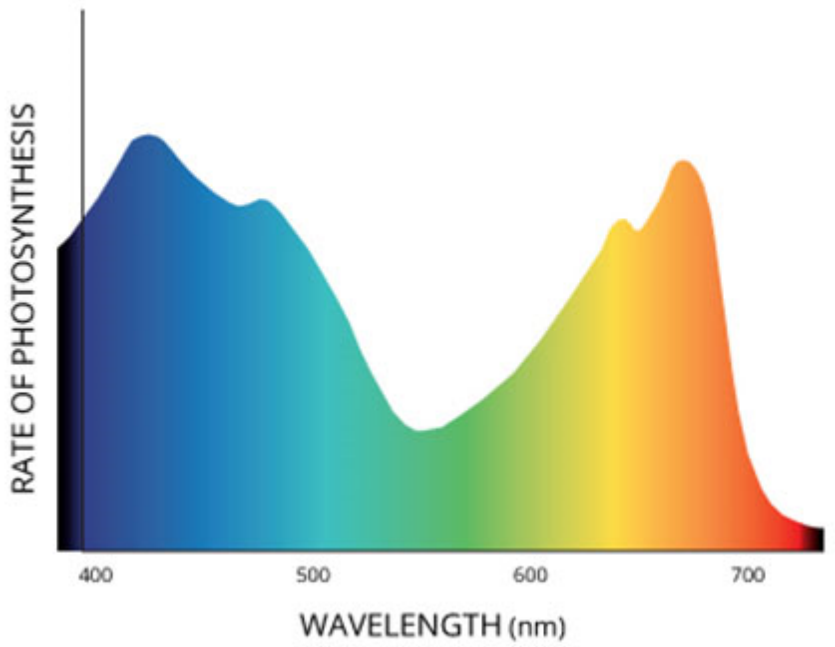
The Spectrum of Lighting: Indoor Applications

In addition to intensity, the spectrum of lighting is critical for growing healthy plants, and in this respect, all bulbs are not equal.

Lights must provide sufficient blue and red wavelengths to support photosynthesis. Blue light is most important for foliar growth and plant health, and red wavelengths are needed for flowering.

With current technology, the best lights for indoor plant growth are metal halide, fluorescent, combination high pressure sodium/metal halide, and induction.

A review of each type of light is presented on subsequent slides.



Type of Lights: Indoor Applications

Metal halide lights are good for growing foliage. They contain a lot of blue light in their spectrum, but appear white in color. They usually require a ballasted fixture and can be sourced in wattages ranging from 25 to 1000; however, there are some internally ballasted bulbs (typically 25 watts) in the marketplace.

Metal Halide Lights

Type of Lights: Indoor Applications

Combination high pressure sodium/ metal halide lights are excellent for growing plants. By using a combination bulb, the spectrum is broadened to support flowering and foliage growth.

Combination High Pressure Sodium/ Metal Halide Light

Florescent lights have a good spectrum, but they may not provide sufficient intensity if mounted from a distance, so ensure close placement to the living wall. Additionally, it may be difficult to find attractive fixtures for these types of lights.

Florescent Lights

Wrong Type of Lights: Indoor Applications

Now that we have reviewed the recommended types of lights to use with indoor living wall systems, let's discuss what types of lights should be avoided.

Halogen and traditional white LED lights used for office space illumination emit white light that does not have the proper spectral components for growing plants. There are blue and red LED lights that will grow plants; however, they are violet-hued and can look very unnatural.

High pressure sodium bulbs lack blue light in their spectrum needed to support indoor foliage plants, and the light they emit tends to look yellow. Their spectrum supports flowering; therefore, they may be a good choice for indoor plants only when combined with a metal halide light.

Maintenance

Maintenance Plan

A maintenance plan is critical to the success of living wall systems.

In addition to listing the supplier-furnished maintenance requirements in the specifications, designers should also clearly indicate who is responsible for caring for the living wall for a specified period following installation.

Problems with living walls are more likely to occur if it is unclear who is responsible for caring for the project, particularly for the period between living wall installation and substantial completion of the building project.

Irrigation: Outdoor Applications

The amount of irrigation applied for outdoor applications will depend on the plants selected, the local climate, season, specific weather patterns, and the wall orientation (south, north, east, west, windward, leeward, high, low, etc.). In most cases, irrigation only needs to run for one or two minutes each day.

Option 1

One way to determine the correct irrigation run time is to visually monitor the plants and soil, then adjust the run time and frequency (of the electronic controller) for the current seasonal weather conditions. Or, simply consult your living wall system manufacturer for a chart of irrigation run time recommendations based upon exposure and average temperatures.

Option 2

An electronic moisture sensor can be used in conjunction with the electronic controller. When the soil becomes dry, the electronic sensor (which is inserted in the soil) tells the controller that it is time to water.

Irrigation: Indoor Applications

Most indoor plants require much less irrigation than most people think. Indoor systems are usually watered once per week for three to five minutes. The best irrigation regimen is based upon thorough moistening of the soil with minimal leaching delivered right around the time that the soil is beginning to dry out (just before the plants begin to wilt). There are several irrigation options to choose from.

Option 1

If the indoor living wall system is fitted with automatic irrigation, initially start with a run time of one minute every other day. Sunny or drafty locations may require four run times of one minute per week. And if succulent plants are used, the run frequencies may be somewhat less. Observe daily and adjust accordingly until you establish a predictable, effective irrigation regimen.

Option 2

Moisture sensor activated irrigation is the fully automated method of irrigating and uses an electronic moisture sensor in conjunction with an electronic controller.

Option 3

Manual watering is quite effective for smaller, easy-to-access plantings.

Plant Maintenance

Annual plants may not require much care at all. At the beginning of each year, they will need to be replaced with new fully-grown annuals.

If perennial plants are used, they will be subject to the typical maintenance of ground level perennial plantings: removal of spent flower stalks, fertilization, and trimming stems and foliage if they become overgrown.

If the plants are deciduous, they will need to be pruned back to the soil level each spring before they break dormancy.

Fertilization

Fertilization requirements will vary somewhat with the plant material, climate, and living wall design.

Some living walls will have an automatic fertilizer injector as part of the system design. Consult the living wall system manufacturer for recommended formulation and application rates.

For hand-watered indoor systems, or automatically-watered outdoor installations without a fertilizer injector, a granular slow-release fertilizer can be applied according to the manufacturer's instructions.

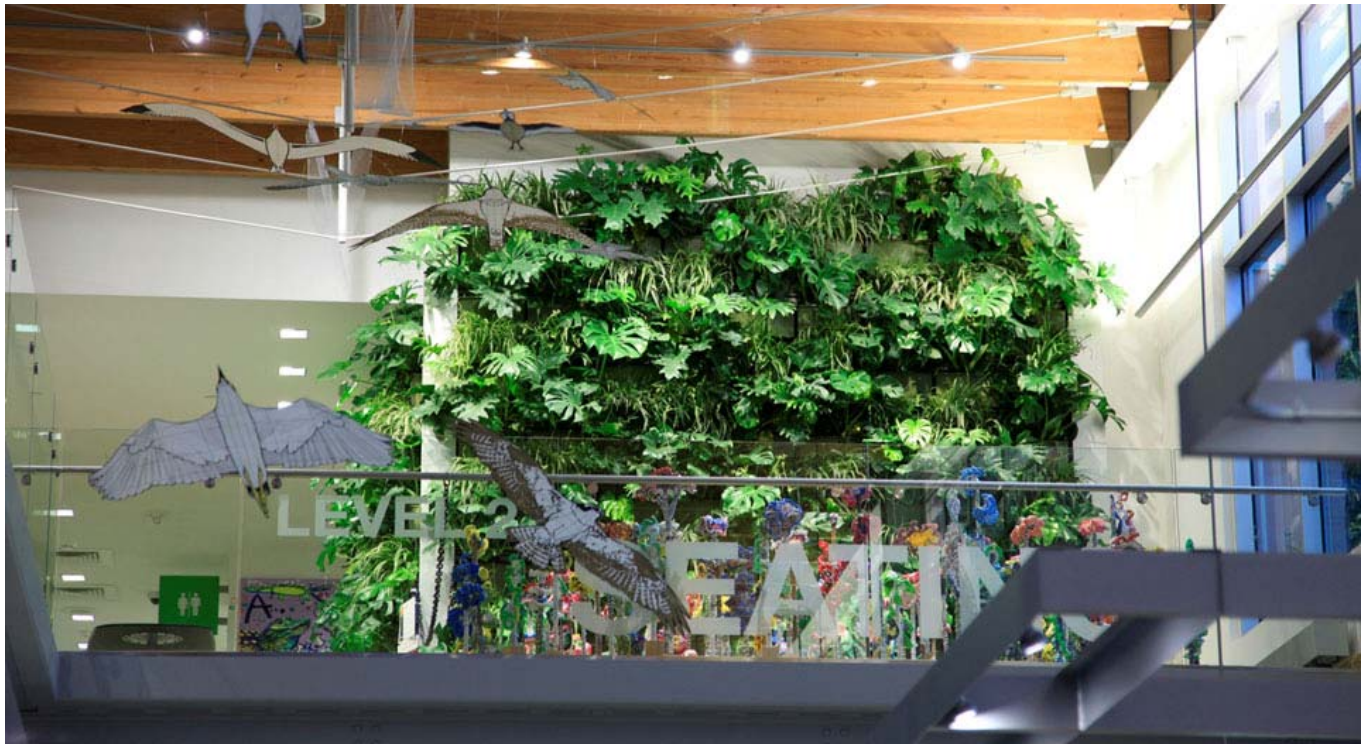
Automatically-watered indoor living walls should not be fertilized with granular, slow-release fertilizers, as these types require water to flow over them to active and disperse the nutrients. Apply liquid fertilizers only to these systems (typically through a fertilizer injector).

Northern Climate Maintenance

In northern climates, outdoor living wall systems must be deactivated in the fall by blowing out the irrigation lines with compressed air and turning the irrigation controllers off. The valves and lines must be emptied to avoid freeze/thaw damage.

After blowing the system out, the rain may effectively water the top few rows and keep the soil moist until freezing occurs. The lower levels can still dry out and should be monitored and kept moist until the soil freezes.

If the soil does dry out after the system is winterized, then the system can be reactivated during warm spells, and the soil irrigated. After irrigation, the system will need to be blown out again.

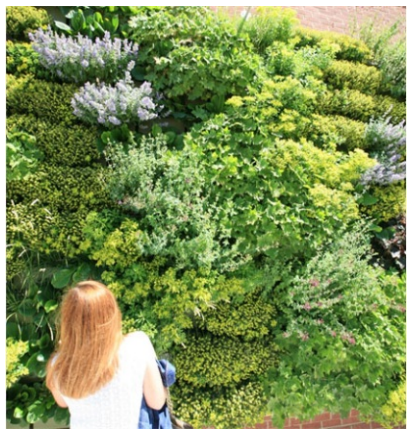


Case Studies

Grand Rapids Downtown Market, Michigan

The Downtown Market is a mixed-use facility that brings together production, distribution, marketing, and education about local produce. The indoor facility features a 24-vendor market hall, while dozens of farmers and artisans sell their products in the outdoor section.

The Market is LEED Gold certified, features a green roof, living walls, geotherm wells, rain gardens, and plenty of other innovative sustainable features.



Lead Architect: Hugh Boyd Architect
Local Architect: Michelle Hoffner, Progressive AE
Landscape Architect: Peter Lazdins, Progressive AE
Construction Manager: Pioneer Construction
Year Installed: 2013

Grand Rapids Downtown Market, Michigan

The design intent was to provide a low-maintenance perennial blend that had a naturalized, random look that complemented the building's architecture.

The structure was installed during the winter, and the planted inserts were pre-grown and planted late spring after the irrigation system was activated.

Maintenance was contracted out for the first year and performed twice monthly. Simple maintenance activities include checking soil moisture and fertility.

May 24, 2013 – Day of Planting

July 12, 2013 – Seven Weeks Later

Grand Rapids Downtown Market: Indoor Living Walls

In 2014, a living wall supplier partnered with the Downtown Market to help broaden their portfolio of design concepts by testing different display plants and patterns, and to increase the vertical green space inside the Market hall.

This vertical garden is unique, as it showcases an unusually broad array of plant material.

Please remember the **exam password PLANTS**. You will be required to enter it in order to proceed with the online examination.

Grand Rapids Downtown Market: Indoor Living Walls

It took approximately 14 man hours to exchange the plants in these walls of the Market hall to make this Christmas display with poinsettias.

December Planting

“Breathe”: Urban Living Art (ArtPrize)

ArtPrize is a radically open, independently organized international art competition.

For 19 days, three square miles of downtown Grand Rapids, Michigan, become an open playing field where anyone can find a voice in the conversation about what is art and why it matters.

In 2014, a living wall supplier entered a living art canvas into this competition, using the artwork to convey a message about the importance of plants in the built environment. The piece was titled “Breathe.”

The living wall entry was voted by the public as a Top 20 finalist of more than 1550 entries, finishing 5th place in the Installation Category.

Preassembled additions to the existing structure were installed a month prior to the competition.

The approximately 1500-square-foot installation was 22 feet tall at its peak. Fifty different plant selections were used in the design.

“Breathe”: Urban Living Art (ArtPrize)

The piece reminded viewers that plants give us more than beauty; they provide the very oxygen we breathe. And, in an urban setting like this, they help restore the natural beauty and greenery that was lost to steel and concrete.

The largest graphic in Breathe faced east and included a windblown pattern in which the white flowers spelled Breathe O_2 (oxygen), and symbolized air. The green patterns, above and below, represented fields and forests. The yellow in the upper right-hand corner symbolized the sun, which fuels photosynthesis, which yields oxygen.

Photosynthesis occurs within leaves, and for this reason the artist included leaf-shaped graphics of Michigan native trees (oak, beech, maple, catalpa), on the north- and west-facing surfaces.

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Conclusion

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