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START

Considerations For Advanced Green Facade Design

CONSIDERATIONS FOR ADVANCED GREEN FACADE DESIGN

Presented By: greenscreen®
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Description: This course examines the required considerations for successful green facade installations and projects and includes discussions on system selection, design, plant selection, maintenance, and client/owner education.

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Considerations For Advanced Green Facade Design

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General CE hours

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Recommended CMP Category:

Acquisition, Installation, and Management of Project Materials

- LEED GREEN ASSOCIATE ☐
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LEARNING OBJECTIVES

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

- promote or make a strong case for the inclusion of green facades as a standard building component on projects based upon relevant and topical issues regarding policy initiatives, energy reduction goals, and shading requirements
- describe the differences between green facades and living walls, and the differences between three-dimensional and two-dimensional green facade systems
- list and discuss considerations that should be comprehensively addressed during design, installation, and post-installation stages of a green facade system, and
- specify a green facade system, describing plant material, soils, planting details, and maintenance programming to fulfill the design intent.

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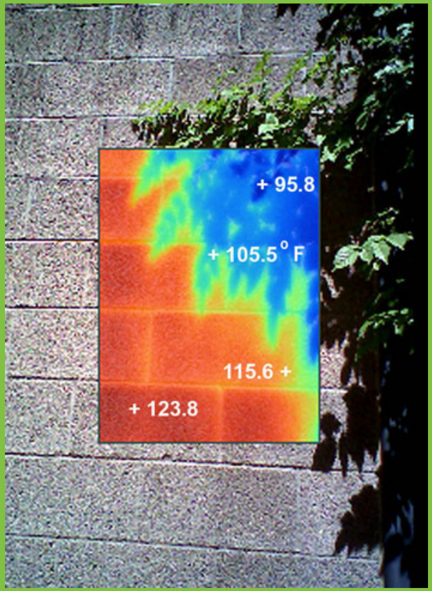
ABOUT GREEN WALLS

To design a successful green facade, there must be a clear understanding of the concepts for creating “green walls.” The term “green wall” describes a vegetated vertical surface and is an inclusive description of two very distinct concepts. Green facades are created by vines and climbing plants that are rooted in soil or containers, growing upwards or cascading down, and that require a structure to maintain their position, develop growth, and survive through seasonal exposures. Green facades are easily scalable and rely on the adaptable characteristics of a broad range of plant species. The term “living wall” refers to a newly developed technology that relies on a prefabricated modular or monolithic vertical soil or hydroponic system to root plants on a vertical plane. This new concept of living walls can also be thought of as a vertical garden, requiring the care and maintenance of a garden with irrigation, drainage control, and nutrients delivered and organized vertically. As any technology in its infancy, living wall systems have had great difficulty with consistent survivability of plant material over large surfaces for an extended period of time. Costs for producing a living wall are easily three to five times the cost of a green facade installation, and living walls have very significant ongoing maintenance and plant replacement operating costs.

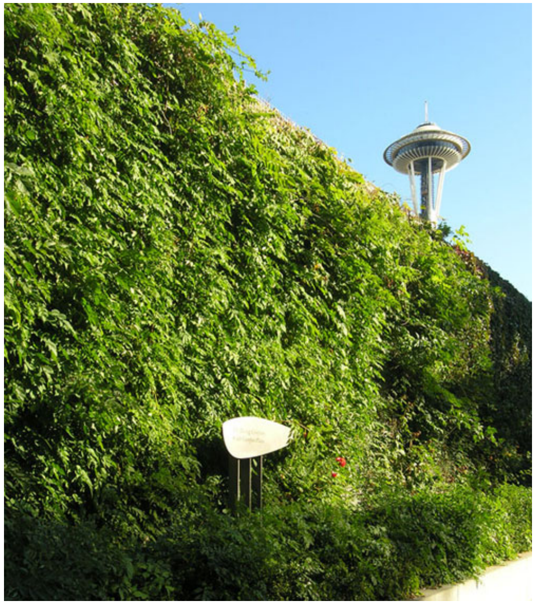
This course focuses entirely on designing and specifying green facades.



DESIGNING FOR BENEFITS

CHALLENGES AND OPPORTUNITIES

The greening and preservation of urban space has become an important consideration for cities, municipalities, and communities, mostly based on the pressure from increased population density on existing infrastructure. As impervious surface area and building sizes increase to meet demand, water quality, stormwater management, and urban heat island (UHI) effect have become primary challenges for designers and policy makers. Seattle, Chicago, and the County of San Mateo, California have implemented design recommendations for the integration of organic, living systems within the built environment, such as green roofs, green walls, and vegetated swales, that can act as a bridge to alleviate the increased demands placed on existing infrastructure.



A long blank surface with a three-dimensional facade system supports a variety of plant species, Seattle, WA.

This concept, also known as Living Architecture, promotes biomass to cool urban areas and supports the growth of tree canopies to improve air quality as well as rain gardens to mitigate stormwater runoff. The Living Architecture concept is multi-disciplinary and requires the cooperation, understanding, and the applied skills of architects, landscape architects, engineers, and horticulturalists. The integration of cross-disciplinary design is the basis for success in identifying and solving the unrealized opportunities between building and site development.

CHALLENGES AND OPPORTUNITIES

A freestanding green facade integrated into a green street demonstration project, Chicago, IL.

Urbanization has created opportunities and challenges in the built environment with the primary goal to increase the energy efficiency of buildings. Building energy consumption and the need for energy efficiency have largely been responsible for the creation of the USGBC LEED® green building certification program, and energy efficiency is currently a net zero initiative for all new and retrofit GSA construction by 2030. Buildings account for over 40 percent of all energy use in the U.S. In 2006, Architecture 2030 issued The 2030 Challenge; it asks the global architecture and building community to adopt the target of a "carbon neutral" state by 2030. The 2030 Challenge also recognizes that buildings are the major source of global demand for energy and materials that produce by-product greenhouse gases (GHG). Slowing, and then reversing, the growth rate of GHG emissions is the key to addressing climate change and keeping the average global temperature below 2°C (above pre-industrial levels).

CHALLENGES AND OPPORTUNITIES

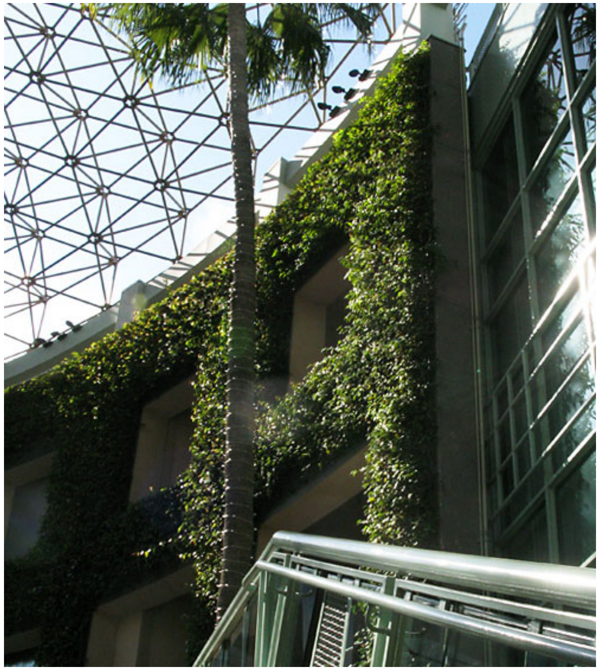
A green facade with climbing vines on a west-facing wall reduces the effects of an urban heat island on a sunny afternoon, Phoenix, AZ.

These targets may be accomplished by implementing innovative sustainable design strategies, generating onsite renewable power and/or purchasing (20% maximum) renewable energy.[1] The implementation of green walls, green facade walls in particular, can help to accomplish the building energy efficiency targets proposed by The 2030 Challenge. Recent research conducted by David Tilley, PhD, at the University of Maryland has concluded that by incorporating a green facade wall on southern and western elevations, existing building envelope R-values for typical residential construction can be substantially increased during the cooling period of summer months, correspondingly reducing energy demand for cooling.

CHALLENGES AND OPPORTUNITIES

Additional conclusions of this three-year study found in common building construction practices:

- green facade walls cool the exterior of buildings by as much as 25°F
- green facade walls reduce indoor air temperatures by reducing the heat flux into the building's exterior walls and indoor space
- maintaining healthy, vigorous plants on a green facade wall can reduce exterior wall temperatures, thereby saving money on cooling costs, and
- green facade walls can improve the energy balance of buildings through reflectance and transpiration.

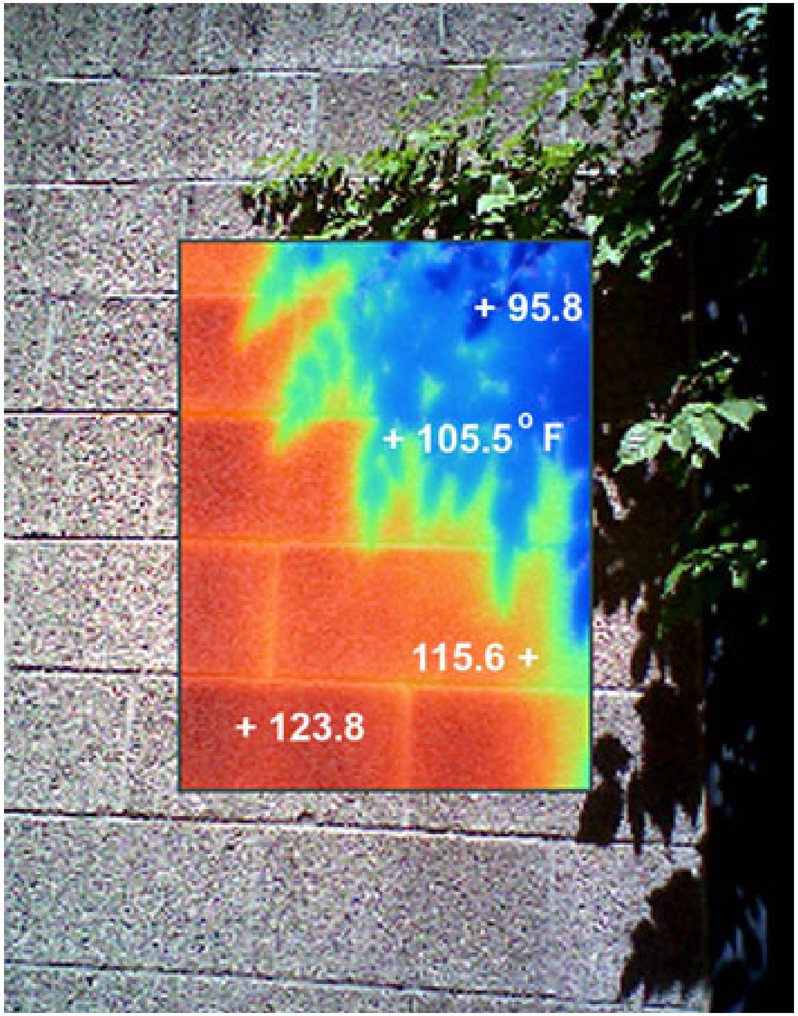


Vegetation shades a building surface and reduces the exterior wall temperatures during the summer months, Universal City, CA.

These conclusions are based on the shading benefits from the vegetation component of green facade walls, and these benefits can help designers achieve desired energy reduction targets. The integration of shading benefits of green facade walls into a building program influences site development, and the added benefits from green walls to other elements of green infrastructure can be developed.

ABOUT URBAN HEAT ISLAND

As urban centers grow, ecosystem services become altered and even replaced. Roofs and pavement compose over 60% of surface area in some cities.[2] These changes cause urban regions to become warmer than their rural surroundings, forming an "island" of higher temperatures in the landscape known as the urban heat island (UHI). Urban heat island effects lead to increased air conditioning costs and air pollution levels, heat and pollution-related illnesses, and even death. Natural, pervious surfaces and vegetation can play an important role in the mitigation of UHI effects. According to the EPA, trees and vegetation lower surface and air temperatures by providing shade and through evapotranspiration. Shaded surfaces, for example, may be 20–45°F (11–25°C) cooler than the peak temperatures of unshaded materials.[3]



Infrared photography demonstrating temperatures on the building surface, Tempe, AZ.

ABOUT URBAN HEAT ISLAND

Green facades create shaded pedestrian areas and reduce UHI effects, Valley Metro Light Rail, Phoenix, AZ.

Plants absorb water through their roots and emit it through their leaves. This movement of water is called transpiration. Evaporation, the conversion of water from a liquid to a gas, also occurs from the soil around vegetation and from trees and vegetation as they intercept rainfall on leaves and other surfaces. Together, these processes are referred to as evapotranspiration, which lowers temperatures by using heat from the air to evaporate water. Evapotranspiration, alone or in combination with shading, can help reduce peak summer temperatures by 2–9°F (1–5°C).[4]

SITES™ / LEED®

The Sustainable Sites Initiative™ (SITES™) specifically advocates for the use of shade trellises and green facades to increase shading. SITES™ is an interdisciplinary partnership led by the American Society of Landscape Architects (ASLA), the Lady Bird Johnson Wildflower Center at the University of Texas at Austin, and the United States Botanic Garden to transform land development and management practices through the nation's first voluntary guidelines and rating system for sustainable landscapes, with or without buildings.[5]

The first LEED® for New Construction completed building in California uses extensive green facades, Irvine, CA.

SITES™ / LEED®

Additional green building certification programs such as LEED® 2009 recognize the inherent shading benefits of vegetation and also promote the use of native plant material to achieve credits within the scoring system. The utilization of regionally appropriate native plant material is a benefit that dovetails specifically with green facade walls. This flexible combination can play a large role in helping to increase coverage of the vegetated area to maximize point totals and make designed landscapes more layered, biologically diverse, and sustainable. In addition to maximizing additional credits within the Sustainable Sites (SS) portion of LEED® certification, the incorporation of green facades can contribute within Water Efficiency (WE), Materials and Resources (MR), and Innovation in Design (ID) credit areas.

DEVELOPING PROGRAMS

An east-facing, three-story, green facade attached to an urban parking structure, Seattle, WA.

Seattle's Green Factor program has been designed to increase the ecological and aesthetic functions of landscape while providing a high degree of flexibility and incentives for new development. The selected strategies, including green walls, encourage layers of vegetation and increased stormwater infiltration in order to shift the ecological function of the urban landscape toward pre-development conditions.[6] The *San Mateo County Sustainable Green Streets and Parking Lot Design Guidebook* implements landscape-based stormwater management facilities countywide and has the potential to minimize pollution, stream degradation, and localized flooding. The maximum tier of "green streets," Level 5, advocates for the use of green walls to allow for the building, site, and street frontage to become one integrated space for stormwater management.[7] A recent study in the UK has found additional benefits beyond stormwater management for green walls within green streets programming.

DEVELOPING PROGRAMS

"A new research study by Professor Thomas Pugh at Lancaster University and other scientists in the UK has found that adding trees, bushes, innovative systems like green walls, or even ivy or other creeping vines, can cut street-level nitrogen dioxide (NO_2) and microscopic particulate matter (PM), two of the worst forms of pollution, by eight times more than previously thought. Many urban streets have high levels of these types of pollution, far exceeding healthy amounts for humans."[8]

Green facade elements help with stormwater management and improve air quality, YVR Light Rail, Vancouver, B.C.

There are additional biophilic, aesthetic restorative, and psychological benefits when integrating green facade walls into projects; research has turned into reality with green walls being incorporated into urban health care facilities and healing gardens. Green facade walls are being introduced into wind modeling to evaluate the effects for site and building design. With this adaptable technology, a strong case can be made for the incorporation of green facade walls as a standard building component that can easily be designed into various project types.

GREEN FACADE SYSTEMS: DESIGN AND IMPLEMENTATION

TWO-DIMENSIONAL SYSTEMS

Green facade systems provide support for plants that have unique structural characteristics and growing habits. Choosing a green facade system that matches up the living plant component with the spectrum of design considerations will be the focus here. Let's look at the two types of structural green facade systems.

Vertical stainless steel cables and horizontal rods are used with multiple connectors for a two-dimensional facade system held in tension.

TWO-DIMENSIONAL SYSTEMS

The first are two-dimensional solutions that consist of vertical cables, horizontal cables, rods, grids, or nets and are made from a variety of materials. Manufacturers have created entire systems of solutions for assembly and attachment to a building facade or vertical plane. 2D cable configurations require being held in tension, and the loading of connectors at the attachment points is a critical factor. The design and placement of the connectors is related to the span of the facade and may require specific engineering and structure to ensure performance under increasing loads. Cable systems and their attachment components are most often made from stainless steel that can add to durability and strength, but that also increases costs. 2D systems are generally installed in a simple plane and require additional structure to create shapes, turn a corner, or modulate a surface. The attachments for cables are shallow in depth, and unless there are additional support connection methods, the green facade will be close to a building surface. If structure is available, a vertical 2D cable facade can be attached at top and bottom but cannot be used for a cantilevered configuration.

TWO-DIMENSIONAL SYSTEMS

Two-dimensional stainless steel cable system with long vertical spans, Dallas, TX.

Rigid 2D system components, from materials like steel or wood, are dimensionally larger than flexible 2D system components, from materials like cables, rods, cable nets, or woven wire fabrics. A primary consideration for designing with a two-dimensional facade system is how the plants inhabit and connect to the facade structure and how the system's design might influence the plant growth and infill of the facade.

THREE-DIMENSIONAL SYSTEMS

The second group of structural solutions for green facades are three-dimensional systems that have unique design capabilities. 3D systems consist of panels that have length, width, and depth, and are created specifically to enhance the growth and maintenance of green facade plants. 3D panels are made from thin gauge steel wire in different ways. One approach uses two wire grids held apart by intermittent wires and welded to a perimeter steel frame for strength in mounting. The wire grids are either woven or welded at various spacing. Structural panel systems are rigid, can span openings, and can be mounted vertically, horizontally, or between structural elements as freestanding facades. Attachment details for 3D panels connect at the perimeter frame, or when using the truss panel, can alternately be located at the edge or within the panel field.

A panel mounting clip holds the facade panel off the building surface, and the depth of this three-dimensional panel system supports the climbing plant, AZ.

THREE-DIMENSIONAL SYSTEMS

Another 3D system uses a structural panel with an integral truss that does not require a surrounding frame for mounting or strength. This modular panel has reduced material weight and provides some unique opportunities to cover large surfaces without perimeter frames, and to create shapes. Panel mounting details are available to allow variable spacing off a building surface, resulting in additional flexibility. 3D panels are rigid, and the attachment design does not require resisting the same tension forces as 2D cable systems. Panel attachments primarily are engineered to resist weight loads and wind forces, and in some cases can be designed for limited cantilevers.

Wall-mounted, modular, three-dimensional panel with mature growth.

The distinct advantage of 3D systems for facade design is the panel depth that provides additional structure for plant material support and long-term maintenance. Vine-type plants require a host to attach to for vertical growth and support, and use a variety of evolutionary characteristics to attach to the host support.

THREE-DIMENSIONAL SYSTEMS

Aerial root species attached to the building surface.

The most obvious plant attachment for a vine is an aerial root system that is so strong it can hold the plant to a building without any additional support. An example would be an ivy or wisteria, both of which are tenacious and can do significant damage to a building facade. Some vines are main-stem twiners, and other vines use tendrils that can twine or curl around another plant or a component of a facade trellis. This group of plants is suitable for 2D systems and generally travels along the cable or rod system, opportunistically attaching. In this case, the plant must develop significantly to infill space between supports and increase its leaf canopy.

THREE-DIMENSIONAL SYSTEMS

Another mechanical plant attachment is leaf hooking, and this involves the leaf pattern and plant strength hooking partially around a host structure until its growth advances to surround the support elements. Many green facade plants can be vine-like in their vertical growth characteristics, but are actually plants that are woody in nature and are runners and scramblers. This group relies on the structural host to support the plant lying upon or growing through the host, and they tend to be plants with long and leggy extensions, such as bougainvillea.

Vine tendril attached to a three-dimensional panel.

Within these various descriptions, some plants prefer to grow directly to the top of the support and then take significant time to spread, and others prefer to be spread early and then continue to grow vertically. Ultimately, the green facade structure design should take into account the growing characteristics of these different plant growth habits. Aerial root plants in close proximity to a building surface will migrate to the building and abandon the facade structure; runners and scramblers may require additional maintenance to establish on a 2D system.

SYSTEM SELECTION

SELECTION PROCESS

After understanding the components of each type of system, a designer needs to make conscious choices regarding the opportunities and constraints to incorporate the appropriate green facade system into a project. The selection process can be linear in fashion, and by completing a checklist of design considerations, successful project implementation can occur. It is important to note that this may not be a comprehensive list, but at a minimum, these considerations should be taken into account. It is equally important to make sure that there is interdisciplinary discussion at the onset of design, as one design consideration from an architectural perspective may affect the landscape architect, landscape contractor, horticulturalist, landscape maintenance contractor, and ultimately, the client.

Modular, three-dimensional green facade system adapted to a tubular steel frame with integrated planters and irrigation, Vancouver, B.C.

SCALE

Scale is a critical factor when proposing and designing green facades. Specific green facade systems have the adaptability to be included on projects as small vignettes, to installations that include entire building elevations. There are basic applications for each type of system, and it is important to understand what the possibilities are for each. Three-dimensional panels are modular and can either be wall-mounted or freestanding while being utilized at both ends of the scale spectrum. Cable systems are tensioned and are limited in their potential for inclusion in freestanding applications. Wall-mounted installations of green facades are considered a building application, but there are possibilities for extending various scales of thematic components throughout the entire site. Consider whether a single system type provides for all design elements, or if a combination of systems is required to execute the proposed design.

Rigid, lightweight, three-dimensional panels being installed on a multi-level building, Golden, CO.

BUDGET

A parking structure with a green facade on all elevations utilizes elevated planters cast into the structure, Suitland, MD.

The most successful means of maintaining a green facade system design within a project's budget is to have it incorporated as part of the building envelope, since landscape-specific applications may have a tendency to be value engineered out of projects. Be certain that budgets include all aspects of a green facade system. Typically, product manufacturers provide a material cost only. Budgets should be adjusted to account for shipping, fasteners, installation of the system components, plants and plant materials, planting bed/soil preparation, and irrigation installation costs. Ultimately, the budget discussion needs to be expanded to include maintenance expenses at the onset of the design process, so that designs can facilitate the long-term requirements of both the physical system and plant material.

CONCEPT CONSIDERATIONS

System selection should be consistent with the conceptual intent of the design. For example, if the conceptual intent is to provide for 100% vegetative coverage on a building elevation, cable systems utilizing a vertical and horizontal layout probably will need to be supplemented or enhanced to achieve the intent. It should also be noted that the growth habit of vining plant material is to grow vertically; extensive, horizontal spans without immediately adjacent plant material underneath will require significant maintenance to achieve the desired conceptual effect. In addition, maximum soil volume allowances need to be considered in the conceptual phase in order to successfully execute the design in the field, and for long-term survivability of the facade planting.

Surface-mounted green facade with plants trimmed to panel edges, Playa Vista, CA.

ARCHITECTURAL CONSIDERATIONS

There are architectural considerations for facade attachment that need to be considered when determining the appropriateness of certain systems. Regional building construction variations can present challenges—a masonry split-faced block will have different attachment requirements from a stucco facade with plywood backing. Attention should be given to attachment locations and whether the building envelope may need to include additional support material in order to facilitate mounting. Mounting locations cannot be located on glazing; the appropriate mounting structure should be determined during the design development process.

Green facade mounting connections are located where appropriate structure is available to cover large surfaces and for surrounding openings, Anaheim, CA.

ARCHITECTURAL CONSIDERATIONS

Matching attachment methods and fasteners to facade materials is critical for meeting exacting specifications, Oakland, CA.

Dead and live loads need to be verified by structural engineers to ensure that the system attachment method is compatible with the type of construction. Product manufacturers should always provide specifics regarding minimum pull out values of fastener types and recommendations for all building types.

ENGINEERING REQUIREMENTS

Snow, ice, wind, and weight loads should always be confirmed by a structural engineer for wall-mounted applications. Post imbed lengths also need to be recommended by a structural engineer for freestanding applications. Wind exposures and engineering requirements also change relative to height/elevation changes, and there are regional building codes that need to be followed. Typically, codes do not allow for green facades to be used exclusively as handrails or crash barriers. Local codes will need to be assessed for ventilation requirements for open and closed space on parking structures. Green facade systems have different component weights; the weight of heavier gauge systems needs to be accounted for. Some 3D systems require a metal frame or trim for attachment, and this additional weight also needs to be taken into consideration for engineering.

Six-story green facade with three-dimensional panels engineered for wind and snow loads, Rockville, MD.

SITE CONSIDERATIONS

Planters with irrigation and drainage mounted to multi-level parking structure, Ridgeland, MS.

A pre- and post-site inventory should be conducted to determine the suitability of planting footprints, available soil volumes, sun orientation, drainage, water availability, and microclimates. This will also help to determine appropriate plant material selection since plants do not respond equally to any of these variables. It is also recommended that a soil test be conducted after construction to determine the macro- and micronutrient levels of existing soils. Consideration should be given to installations that occur within areas that experience snow events. Snow removal and storage should be discussed with facility managers and landscape contractors in order to prevent any damage to the system and/or plant materials from these future activities.

BUILDING CODE CONSIDERATIONS

Local building codes regarding right-of-ways (ROW), landscape ordinances, and easements should also be consulted. Sometimes, green facades extending from a building wall can extend into easements or ROWs, and consideration for the dimensions of the planting area must be taken into account. More and more local landscape ordinances are advocating for the incorporation of green facades to help alleviate potential zoning use issues. There may be certain height requirements that must be met in order to achieve compliance.

Seven-year-old installation of trumpet vine with 40-foot height and six-inch caliper, Fullerton, CA.

ENVIRONMENTAL CONSIDERATIONS

A thorough site inventory will help to identify most environmental considerations that need to be taken into account, but additional thought should be given to basic plant functions, tolerances, and characteristics.

In urban environments that experience snow events, salt injury can be detrimental to plant material and soils. When salt accumulates in the soil, excessive sodium (Na) from salt destroys soil structure, raises soil pH, and reduces water infiltration and soil aeration leading to soil compaction and water runoff. Build-up of deicing salts in the plant can interfere with photosynthesis and other plant processes like respiration and transpiration.

Salt tolerance of plant material is also a consideration in coastal environments. Plant functions should be determined since some plant material produces blooms that are attractors to pollinating insects, such as bees, while other plant material like grape vines produce fruit that may stain adjacent surfaces. Drought continues to be a major environmental factor in most parts of North America. According to the National Weather Service Climate Prediction Center, in August 2012 drought covered over 60% of the 48 contiguous states, and ¼ of the U.S. was experiencing extreme to exceptional drought.[9] Drought creates an increased demand on water resources, and in these conditions, native plants and drought-tolerant plantings are strongly recommended.

ENVIRONMENTAL CONSIDERATIONS

This rain garden with integrated green facade is a key component to the stormwater management strategy, Oakland, CA.

Environmental considerations should take into account the water use requirements of the entire site and the balance between usage, efficiency, and conservation. Opportunities to include green facade systems within rainwater harvesting and greywater technology can occur on many projects and should be strongly considered in drought-stricken areas. Conversely, green facades can also play a role within stormwater management plans for handling surface runoff and the reduction of off-site water discharge. Green facades have been successfully incorporated into vegetated swale and rain garden projects. Native vine varieties that thrive in seasonally inundated conditions should be considered for bioretention or additional low-impact development techniques.

SOIL VOLUME CONSIDERATIONS

The amount of soil that is made available for plant's roots to grow into is a consideration that is often not taken into account. Soil volume is critical for the long-term success of plants in all locations regardless if in the ground or in planters. Historically, determining appropriate soil volumes for plant material has been based upon research looking at shade tree survivability in urban environments. The most significant body of work in this area of research has been forwarded by James Urban, FASLA in his book *Up By Roots* (ISA Press 2008). Urban's research states that a 16" caliper tree requires 1,000 cu.ft. of available soil volume or 2 cu.ft. of soil volume for every 1 sq.ft. of crown.

SOIL VOLUME CONSIDERATIONS

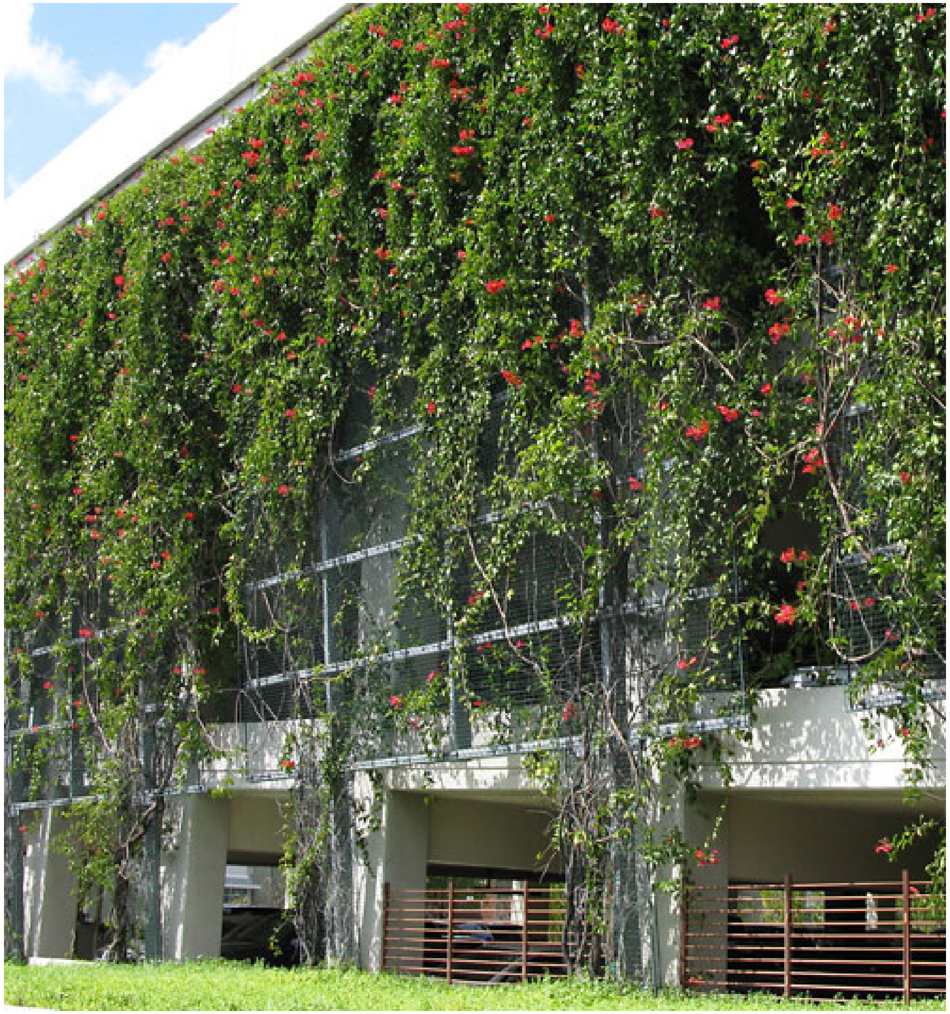
Based on research as a guideline, the following soil volume recommendations can be extrapolated for vines:

2" caliper = 100 cu.ft.	5'W x 10'L x 2'D
4" caliper = 200 cu.ft.	10'W x 10'L x 2'D
6" caliper = 400 cu.ft.	10'W x 10'L x 4'D

Visual observation of green facade installations over 15 years old has shown that vine plant material can reach caliper dimensions of six to eight inches. At-grade planting beds with an unlimited available soil volume provide the best option for maximum plant material height and spread.

Appropriate climbing vine varieties can reach to four stories with adequate soil volume, fertilization and maintenance, Silver Spring, MD.

PLANT CONSIDERATIONS



These vines planted directly into the ground have ample soil volume and correct spacing for full coverage to four stories, Fullerton, CA.

Appropriate plant selection is critical to the success of green facade systems. In addition to simply determining a plant's hardiness, there are certain minimum requirements that must be determined to assess the appropriateness for each system. Twining and vining plants are conducive to cable and cable net green facades, while vines that cling, or climb with tendrils or suckers may be utilized on three-dimensional systems. Some shrubs that have vertical growth habits, such as climbing hydrangea and sunspot euonymus, may also be successful on a three-dimensional system. Clients/owners should be made aware that evergreen plant materials, such as English ivy, can be problematic in northern climates without significant maintenance.

PLANT CONSIDERATIONS

English ivy is typically used as a horizontal ground cover; to maintain this plant as a vertical element, vines need to be attached directly to green facade systems with regular pruning maintenance. Plants also can have a specific mature height and varying growth rates to achieve mature height. Priority should be given to regionally native plant material since it is typically drought tolerant and adaptable to local weather conditions. Regionally native plant material can also be more resistant to pests and diseases. As a rule of thumb, designers should strive for mixed planting designs that offer diversity and seasonality, and eliminate the establishment of plant monocultures.

Regionally appropriate, native plant material installed with correct spacing begins to fill a freestanding green wall, Atlanta, GA.

The number of plants to incorporate into a system should also be given attention. Typically, cable systems require one plant per vertical cable, while multiple plants can be used on 3D systems. Plant spacing on 3D systems can vary greatly and is determined by the size of plant material upon installation and expected mature size.

PLANT CONSIDERATIONS

Proper soil volume, irrigation delivery and maintenance are successfully demonstrated in this 18-year-old green facade installation, Universal City, CA.

The following guidelines can be used to help determine plant quantities, but consultation with local landscape architects, native plant societies, landscape contractors, and horticulturalists is strongly recommended:

#1 Container 18"–24" o.c.

#3 Container 24"–36" o.c.

#5 Container 36"–48" o.c.

#7 Container 48"

When making appropriate plant selection, please note that a small number of vines have been identified regionally as invasive and therefore should be avoided, especially if the installation is adjacent to undeveloped, open space or natural areas. The USDA maintains a database that reflects current information regarding regionally introduced, invasive, and noxious species.[10]

IRRIGATION CONSIDERATIONS

Everything that grows needs water and irrigation, and green facade systems typically fall into one of two categories. An at-grade planting bed with typical vine plant material is the most common application. These planting plans can be watered within the scope of a standard irrigation plan. Within a green facade system planting, there is no need to water any part of the plant other than the root zone. Raised planters or container planters are the other type of application, and water source should be a conscious determination, especially if included in a rooftop application.

The facade plants are pruned at the pedestrian level to create a shade canopy above, Valley Metro Light Rail, Tempe, AZ.

These installations most likely will have a defined soil volume. While that is a very critical consideration, frequency of watering and drainage within the soil volume is also paramount to the survivability of the plant material. Additional investigation should be given to the type of soil medium or mix that is being incorporated into the planter. An irrigation professional should be consulted in any installation in order to determine delivery system, watering frequency, rate, and irrigation source.

MAINTENANCE CONSIDERATIONS

Unfortunately, maintenance for a majority of green facade installations is either too infrequent, or more accurately, non-existent. Green facade systems are one-half static system and one-half living system. Designers of these systems can play a critical role in educating the client/owner regarding appropriate design of a system to make it easier for typical horticultural maintenance practices that will ensure the long-term success of the total system. Special attention should be given in the design phase to installations that are over eight feet in height, since anything taller will require the use of a ladder to properly maintain plant material. Additional attention needs to be given to installations that will require maintenance on multiple-story projects.

A well-maintained, freestanding application with a narrow planting area helps to screen views, define space and provide circulation control, Universal City, CA.

A comprehensive design program will specifically address how maintenance professionals will access or gain access to plant materials, irrigation components, and soils requiring nutrient delivery. Access for maintenance is critical, and consideration needs to be given to where ladders, scissor lifts, and even bucket trucks can be located in order for the proper horticultural maintenance of green facades.

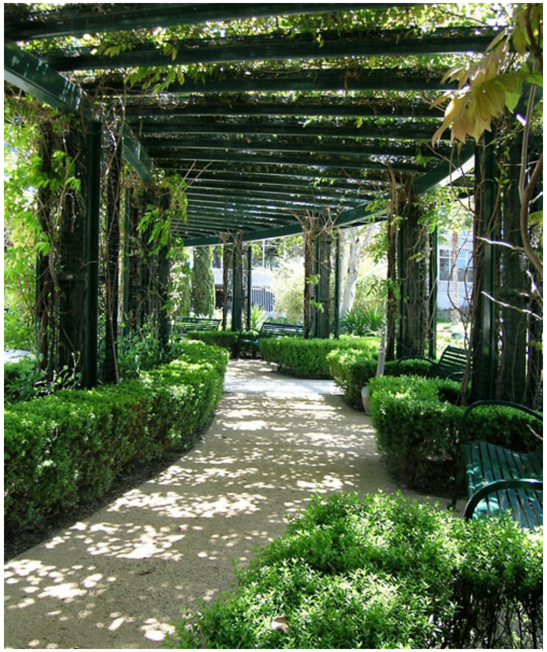
MAINTENANCE CONSIDERATIONS

Wall-mounted, modular, three-dimensional panels with standoff brackets provide access to keep plants off the wall, Oakland, CA.

Conscious design decisions also need to address the clearance between the wall and the back side of the green facade system. Systems that are held within six inches or closer to structure will need to have specific plant material that twines in order to prevent attachment of the plants to the building facade. A clearance of 18 inches from the wall is recommended for wall-mounted installations over eight feet tall; this will allow sufficient space to prune plant material and provide access behind the system. Design decisions can and will affect the maintenance and long-term success of the green facade system.

LIFE CYCLE AND SUSTAINABILITY CONSIDERATIONS

How long do we expect these systems to last—5, 10, 15, 30, 50 years? Experience has shown that systems that are well-maintained, both physically and horticulturally, can last 18 years or more. Product manufacturers that have completed a life cycle assessment (LCA) are using 30 years as a baseline for product life cycle, and plant material can last for centuries given ideal conditions. Project design and system selection should take into account an extended life cycle time frame; consideration should be given to the possibilities of landscape renovations and alterations.

A before and after showing plant material growth during a five-year period on a public shade structure designed to last many years, Playa Vista, CA.

SPECIFICATIONS

As previously described, not all green wall systems are alike. Product specifications are written to guarantee that a client/owner is getting exactly what is designed for a certain application or need. Since there are many variations within green facade systems, strict adherence to specifications must be maintained so that acceptable substitutes are compared on an equal basis. Manufacturers that provide three-part specifications should be identified and utilized.

A wall-mounted, modular, three-dimensional, green facade system with plants showing seasonal interest, Chicago, IL.

EXPECTATIONS AND SURVIVABILITY

System selection, expectations, and long-term viability will be different depending on the diversity of the design team. The key to long-term success of a green facade system is to include as many disciplines within the design process as possible. As documented here, green facade systems can be far-reaching in their scope and adaptability.

One important design consideration is expected life cycle of the green facade system. Some projects will be legacy projects maintained for decades, while others may be in place for a shorter period to keep in line with current design trends. If a project is expected to be replaced or renovated within a shorter time frame, systems that are conducive to Design for Deconstruction (DfD) principles should be utilized. For example, retail and hospitality projects typically have short design durations, and some high visibility projects are typically renovated or reconstructed within a 12–15-year landscape plan.

Many resources are available, and multiple disciplines need to be included in order to achieve expectations. One of the best tools for managing expectations is to complete a post-occupancy evaluation (POE) after installation. Either formally or informally, POEs are a great way to engage clients, designers, facility managers, and contractors to determine successes and areas of improvement on both existing and future green facade projects.

ENSURING THE INSTALL:
A CHECKLIST FOR SUCCESS

PROJECT SUCCESS

After a green facade system has been selected and all of the design programming has been completed, the design team should initiate the shop drawing process with the product manufacturer. Shop drawings are an important tool that will expose any deficiencies or oversights in the construction documents and design. Another important tool that can be utilized to ensure a successful project is an installation checklist. Installation checklists can include a wide variety of considerations and help to create awareness between designers and contractors. Since green facades can be complex installations, the following are just some of the items that might be included on such a list.

Coordination between the designer, field dimensions, shop drawings and product manufacturer is critical for complex projects, NY.

SCOPES AND CONTRACTORS

The type of green facade system and installation will dictate the contractor's scope of work. Large, multi-story, wall-mounted installations typically will be awarded to contractors that have experience with building veneer, concrete precast, and tilt up systems. These contractors are capable of working at higher building elevations and are familiar with attachment considerations such as no-drill zones. Miscellaneous metals and structural steel contractors are typically best qualified to build large, freestanding green facade applications that require a steel support system. Plant material installation as well as the irrigation installation will be completed by another contractor.

Matching contractors with appropriate scope of work and equipment will help alleviate installation issues, Riverdale, MD.

CONTRACTOR QUALIFICATIONS

Green facade panels are incorporated into a freestanding fence for use as a wind break on this medical campus, San Mateo, CA.

Simple wall-mounted and freestanding fence installations can easily fall under the scope of landscape contractors. This is an excellent way to combine the green facade construction, landscape contracting, and irrigation scopes. For larger freestanding fence projects, fencing contractors can be very efficient and are experienced with post layout and post imbed requirements. Recently, specialized green roof installers have been including green facade systems under their scope of services. These contractors are already familiar with working on rooftop installations, and green facades can require specific considerations, such as roof deck penetrations and parapet wall attachments. At a minimum, contractors should be familiar with accurately estimating installation costs of the green façade system and the scope of work to be performed, and be able to successfully complete the installation according to approved shop drawings. Additional qualification considerations can be assessed on a project-by-project basis.

TRAINING AND EXPERIENCE

Priority should be extended to contractors that have past experience with installing the specific green facade system. Some green facade product manufacturers might provide installation training and certification to contractors. Also, product manufacturers might have preferred installers in certain areas and should be able to provide a listing of contractors that have placed purchase orders in the past.

KIT OF PARTS

Coordinating lead times and delivery timetables for complex projects requires effective communications between the manufacturer, designer and contractors, Phoenix, AZ.

Designers and contractors need to be familiar with the components of green facade systems and what is required for installation purposes. What does the product manufacturer provide and what additional requirements, such as fasteners, etc. are required to complete the installation? What are the lead times? How are the shop drawings delivered? In addition, contractors should familiarize themselves with how the system will be delivered to the job site. Initiating proper lines of communication between designer, product manufacturer, general contractor, and subcontractor can help to manage expectations and effectively coordinate scheduling for the installation.

SCHEDULING

Project complexity will be the main driver of job site scheduling and coordination. Installations that require multiple contractors and scopes will require linear project management in order to have a successful completion. A basic green facade installation sequence should be the construction of the static green facade system, followed by irrigation installation, if required, and then plant material. If multiple contractors are performing different scopes, it might be beneficial to complete any punch-out inspections before moving on to the next step.

Multiple, three-dimensional panels with easy maintenance access help to reduce reflected light and heat gain in an arid environment, Las Vegas, NV.

PUNCH OUT

Understanding what to look for during the punch-out process is vital to the long-term success of the green facade system. As far as the static system is concerned, there are two specific areas that require attention. The attachment system should be examined to determine if adherence to installation specifications were met. Especially on projects that are designed to meet exacting engineering requirements, proper clip placement, proper clip spacing, and panel connections need to be inspected for compliance. On wall-mounted applications where fastening systems penetrate the building envelope, waterproofing integrity needs to be maintained and should be assessed.

The other area that requires specific attention is the exterior coating of the static system. Powder coated green facade systems can be compromised during installation, and any exposed metal surfaces need to be re-sealed with an approved touch-up product. This is also critical if there have been any field modifications made to the green facade system. Any incidental metal filings that have collected on the system need to be removed in order to prevent surface rust staining.

PUNCH OUT

For the living system evaluation, there are two components that need to be inspected for design compliance. Irrigation systems need to be evaluated to determine if proper coverage is being achieved. Additional verification should include proper delivery rate, duration, and frequency of delivery. Plant material should be examined to determine if specified sizes are installed; that they have not incurred damage, have proper spacing, and are properly attached to the static system; and if proper mulch depths are maintained. The inclusion of a recommended planting detail within construction document submittals is an excellent way to prevent landscape contracting deficiencies in the field.

Proper plant installation and irrigation placement are critical to the success of green facade systems and should be inspected upon completion, Golden, CO.

WARRANTIES

Inspection of system components and plant material is crucial for proper specification enforcement, Tempe, AZ.

Product manufacturers provide warranties that are specific to their static green facade systems, and guarantees vary. Check with the product manufacturer to determine what coverage is provided. Plant material warranties should be provided by the landscape contractor. Plant warranties typically guarantee plants to be free of disease or damage, and plant survivability is the responsibility of the contractor for one year.

GREEN FACADES:
A STANDARD BUILDING COMPONENT

ADDITIONAL REQUIRED DISCUSSIONS

In addition to these important considerations, there are two further discussions that need to occur to ensure a successful green facade installation. One needs to be centered around client/owner education regarding the maintenance aspects of both the static and living systems that are inherent with green facades. The client/owner should be made aware of these two distinctly different components and the maintenance strategies necessary to ensure success. Maintenance should be mandatory for all green facade installations to make sure that this capital expenditure appreciates in value, and budgets need to be established in order to fulfill this requirement.

High-use public projects require routine maintenance to ensure long-term survivability of the living system, Washington, D.C.

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ADDITIONAL REQUIRED DISCUSSIONS

Inspecting and evaluating installations can be a productive step to help meet client expectations, Anaheim, CA.

The final discussion needs to determine how and why green facade systems are deemed successful. This is very important to move the industry forward and to make certain that the technology is being utilized to its fullest capacity. Metrics should be defined that will identify what makes installations fail or fall short of expectations and goals. One tool that can be very helpful in determining the metrics are post-occupancy evaluations (POE). Performing POEs on projects can either be a formal or informal process, and the insights can be very enlightening pertaining to the intricacies of the design process, responsibilities, and post-construction condition of the installation. In addition to POEs, project case studies are an excellent way to document the particulars of installations, and a collective scope and body of work can be established quickly and easily. There is also a need to develop an industry standard maintenance and performance specification. Green facade designers, contractors, and product manufacturers should be proactive in assembling and forwarding maintenance and performance specifications in order to establish an acceptable standard.

CASE STUDIES

CASE STUDY: STUDIOS 5C

Credits
Client: Studios 5C
Architects: RSP Architects
Installation Contractor: Sigma Contractors

Site Specifics
Completed 2001
100 trellis panels with full perimeter trim
3707 sq.ft. trellis panels
$6.71 cost per sq.ft.

Mounting
Hardware to structural steel

Studios 5C, located in Tempe, AZ is a 21,000 sq.ft. urban mixed use building in the Mill Avenue District of Tempe. It includes a ground floor brewpub with sidewalk patio, offices for an architectural firm, and a series of executive suites which cater to design professionals.

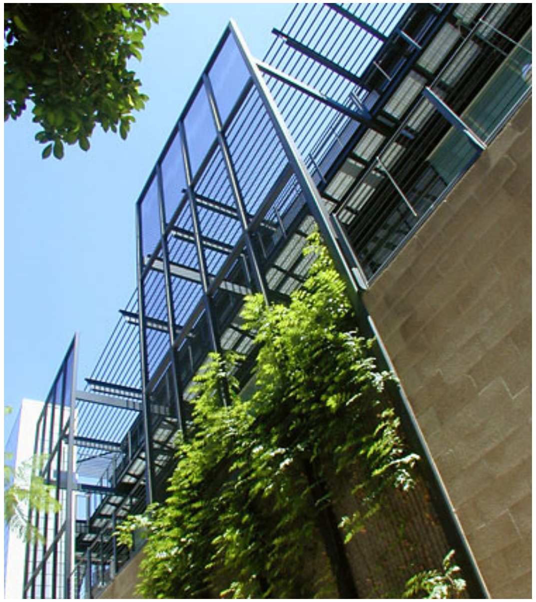
Green facade technology can create shade that cools building surfaces, and also provides privacy screening.

CASE STUDY: STUDIOS 5C

Creating shade while screening views and allowing for air circulation are challenges that are magnified when designing in a desert climate. Designed by RSP Architects, this building employs strong massing and honest expression of materials to harmonize and stand out in its urban context. Innovative design is used throughout Studios 5C to help solve the environmental considerations that must be accounted for in an urban desert environment. On the exterior stair and balcony access, shade and screening are created by multi-story structural steel components that are infilled with trellis panels that facilitate the growth of climbing vines. The 3,707 sq.ft. of lightweight trellis panels are attached to the steel by a custom slot in the full perimeter trim of the panels with retention clips. A very narrow planting bed of only 14" is enough space for vines that climb to more than 40', forming a flowering vertical tapestry.

CASE STUDY: STUDIOS 5C

The exterior staircase is cloaked on two sides, shading this volume and creating a semi-enclosed tower that is significantly cooler than the outside desert temperatures. The combination of interrupting solar heat gain along with the microclimate created by the evapotranspiration of the plants is very successful in keeping a comfortable temperature range. Infrared photography studies reveal how temperatures of building surfaces collect and radiate heat gain, while shaded areas and plant leaves are considerably cooler. Leaf surface temperatures are at or near the ambient air temperature during evapotranspiration, and in some cases are actually 3–5°C cooler.



CASE STUDY: PREMIER AUTO GROUP

Credits
One Premier Place
Client: Ford Motor Land Services Corporation
Project Design Architect: LPA, Inc.
Construction Manager: Koll Construction
Environmental Design Consultant: William McDonough & Partners

Site Specifics
Completed 2002
467 trellis panels
16,241 total sq.ft. green facade
$6.65 cost per sq.ft.

Mounting
Standard clips and hardware to structural steel supports

300 feet of freestanding green facade provides security, shade, and privacy screening, Irvine, CA.

Project Update: In 2010, after selling off the Aston Martin, Land Rover, and Jaguar brands, the Ford Motor Company leased the 181,000 sq.ft. office tower to Yum Brands, Inc. of Louisville, KY, and the space is now home to the corporate headquarters of Taco Bell.

CASE STUDY: PREMIER AUTO GROUP

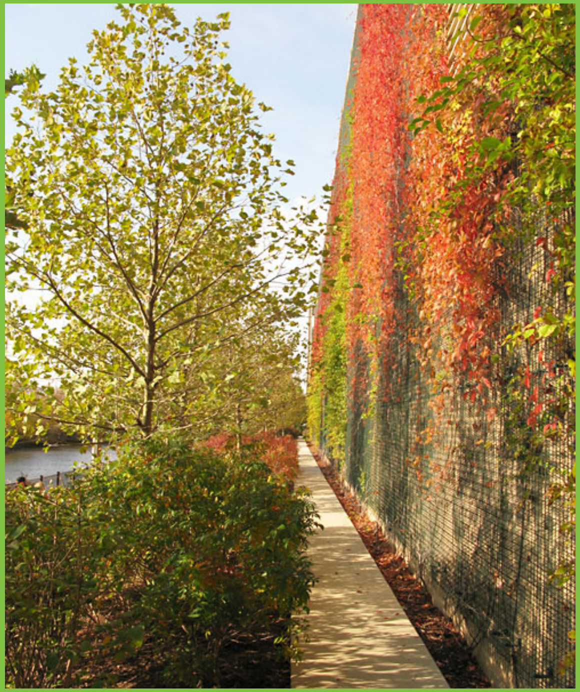
In early 2000, Ford Motor Company announced that it was constructing a 300,000 sq.ft. Class A facility and moving its Premier Auto Group (PAG) headquarters to Irvine, CA. The new facility, named One Premier Place, would include an 181,000 sq.ft. office tower, 90,000 sq.ft. product development wing, conference center, vehicle display area, fitness center, and cafeteria. The facility would also be the first completed LEED for New Construction™ project in the U.S. and includes multiple green facade walls to provide shading benefit and help to screen adjacent vehicular traffic from interior office space. The project consists of 16,241 sq.ft. rigid, three-dimensional trellis panels in three specific applications.

CASE STUDY: PREMIER AUTO GROUP

1. An 18' tall freestanding installation surrounds a storage area of the Product Development wing and connects the green roof with at-grade planting beds. Fully vegetated panels effectively screen the storage area from an adjacent access road and provide an attractive buffer in a narrow planting strip.

2. An additional installation extends 300' across an entire elevation, effectively screening surface vehicular circulation from the cafeteria area, ground floor, and second story offices. This freestanding application reaches 20' tall and also provides a secure area for on-site day care operations.

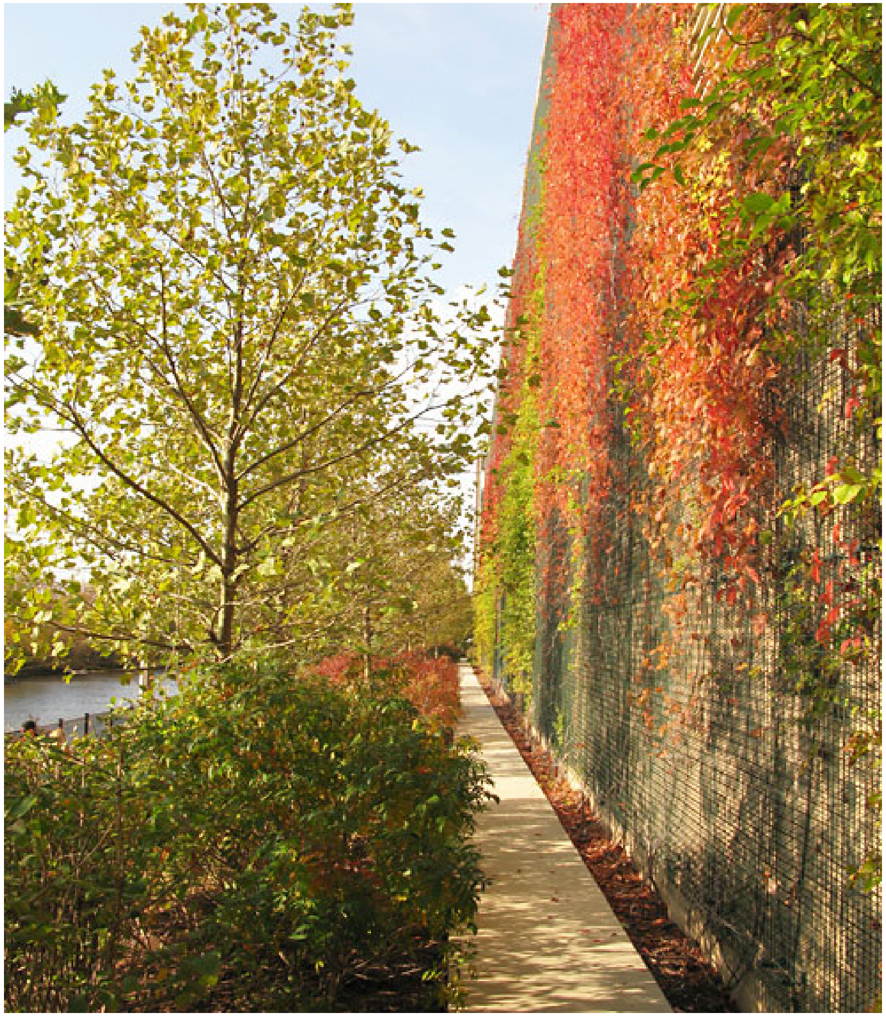
3. A third installation is incorporated into a wall-mounted, steel support structure attached to a four-story parking facility. The 24' tall stacked panels tone down the monolithic architecture of typical parking structures and provide a vertical “green ribbon” visual aesthetic that thematically ties the building programming to the landscape.



SUMMARY AND RESOURCES

SUMMARY

For building energy efficiency, durability, natural beauty, cost effectiveness, and adaptability, green facades offer the design community a substantial asset. The green facade industry continues to evolve; there are a significant number of projects that have thrived for more than a decade, demonstrating a long-range return on investment. Installation techniques and construction adaptability will continue to improve, and innovative design applications will be further advanced as designers continue to push the envelope for green facade inclusion. The case for that inclusion can be strengthened by taking the described considerations into account. The completion of this outlined process will help to establish a mainstream acceptance of green facades as a standard building component.



A large-scale green facade contributes to an award winning project for an 80,000 sq.ft. retail flagship location, Lincoln Park, IL.

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10. Natural Resources Conservation Service. "Introduced, Invasive, and Noxious Plants." *USDA.* http://plants.usda.gov/java/noxiousDriver

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RESOURCE LINKS

The Sustainable Sites Initiative™ (SITES™) Credit Contribution Review
http://greenscreen.com/Resources/SITESREVIEW_v11.pdf

LEED® 2009 Credit Contribution Review
http://greenscreen.com/Resources/greenscreen_LEEDCredits_v11.pdf

Recommended Plant List by Hardiness Zone
http://www.greenscreen.com/greenscreenPlantList_v1.pdf

Introduction to Green Walls: Technology, Benefits, and Design (2008)
http://www.greenscreen.com/Resources/download_it/IntroductionGreenWalls.pdf

Considerations for Advanced Green Facade Design White Paper
http://www.greenscreen.com/direct/GS_AdvancedGreenFacadeDesign.pdf

All sites accessed November, 2012.

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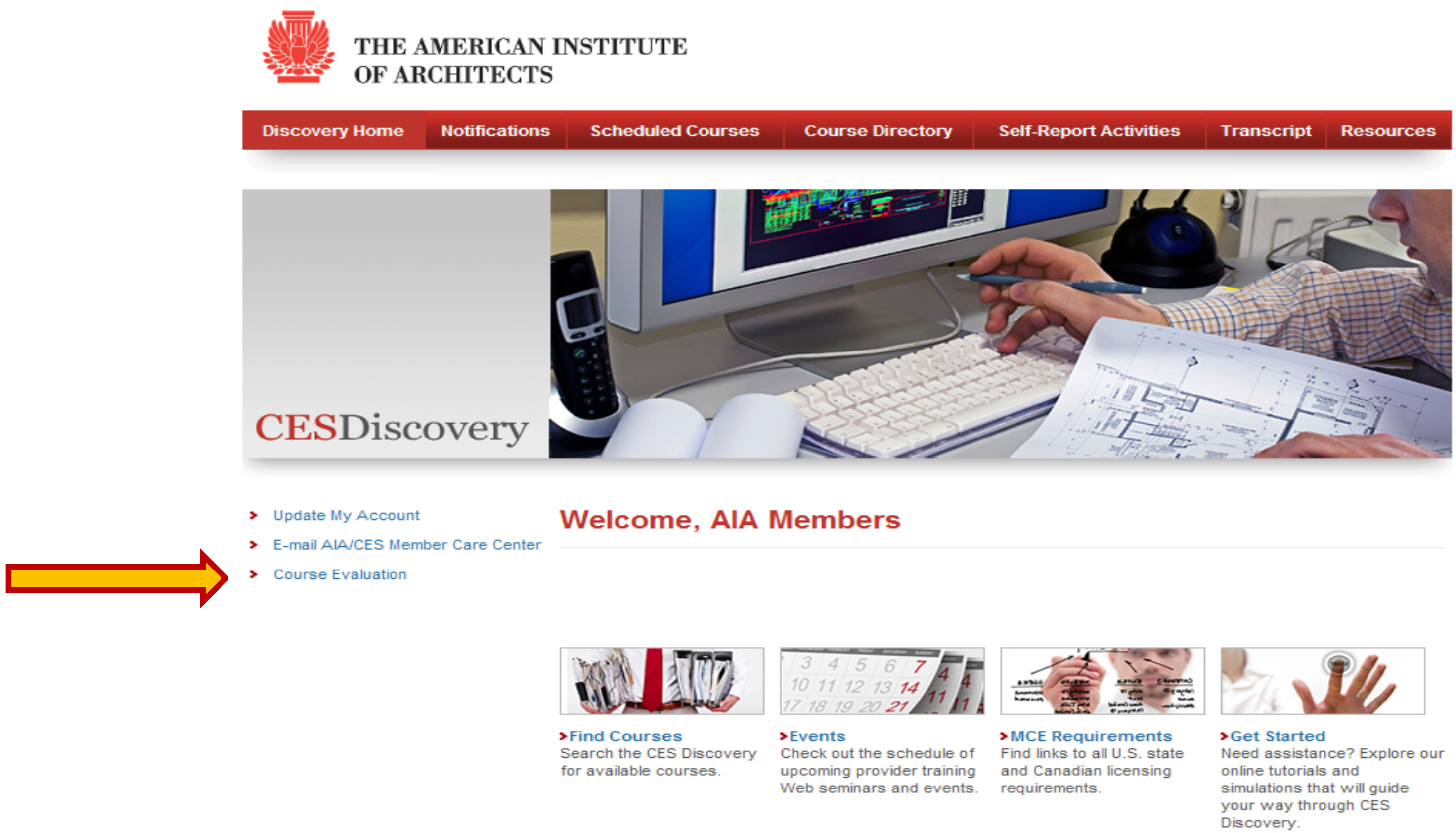

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