Experiential Design

BY JOE DOUGLAS WEBB, AIA

The Gulf Freeway Office Building in Houston is the fourth of four buildings designed for the same owner. The two-story, core and shell office building has 24,084 conditioned ft² on 1.68 acres. It was completed in May 2010 and was 40% occupied as of July. Occupancy is expected to increase to 60% soon.

Vegetative Roof
Integral to the building is a 15,781 ft² intensive vegetative roof that is a minimum of 10 in. deep. The roof retains 73% of all rainfall that strikes the surface and provides an R-value of 66. Additionally, it removes approximately 650 pounds of airborne particles annually and produces enough oxygen per day for 975 people.

Based on their experience with vegetative roofs, the designers have developed a methodology to evaluate the evaporative cooling capacity of the roofs on a monthly basis along with solar radiation mitigation. The Gulf Freeway roof at its peak performance provides the equivalent of 65 tons of HVAC capacity offset because of the evaporative cooling, and 79 tons due to solar radiation mitigation.

The decision to incorporate a vegetative roof, especially an intensive vegetative roof in all four buildings, has been affirmed by the performance. Intensive green roofs are typically deeper and designed to create more of a natural landscape than extensive green roofs, which are shallower with shorter plants. Cheyenne One (see Building on Experience, p 52) incorporated a multistage, air-cooled chiller of 250 tons because the designers did not yet understand the impact of having a vegetative roof. This was the impetus for the designers to create the evaluation methodology for the roofs. To date, the Cheyenne One system has only used 100 tons of capacity at most.

Cooling Benefits
Cheyenne III benefited from what the designers learned from Cheyenne One. It incorporates a 140 ton, air-cooled, rotary scroll chiller. This building has an area for specialty medical device manufacturing that requires strict temperature, air quality and humidity controls. The existing building systems easily handled these requirements. No system modifications were necessary.

At Cheyenne One, monitors that have been in place since the building’s activation feed data into the building management system. Temperature sensors are located in the air above the roof, buried mid-depth in the soil mixture, and at the bottom of the soil mixture immediately above the drainage/ filter media.

The air temperature in the summer is usually in the low to mid-90s or higher. The mid-depth sensor typically reads temperatures in the mid-80s, and the base sensor typically reads in the low 80s or upper 70s. Moisture content directly impacts these ranges. As a result, the HVAC systems only have to address a temperature differential of 10 to 15 degrees at the underside of the roof.

Energy savings success for four similar office buildings in Texas started with planting native vegetation on one roof. This provided designers with a living lab to test what sort of savings can be achieved with vegetative roofs and led to the discovery that they could significantly reduce the amount of chiller capacity needed simply because of the insulation value of the soil and plants.

Above: This image of Cheyenne One’s vegetative roof was taken six days after Hurricane Ike hit Houston in 2008. Although a neighboring building lost part of its facade and roof, the 120 mph winds and 11 in. of rain did not damage Cheyenne One’s roof.

Opposite: The roof overhang and balcony on the eastern, western and southern faces of the Gulf Freeway Office Building prevent glare and heat gain. Stone and plaster are used in the building’s exterior design.

CASE STUDY
FC GULF FREEWAY OFFICE BUILDING

Building at a Glance

Name: FC Gulf Freeway Office Building
Location: Houston
Owner: FC Gulf Freeway
Principal Use: Office
Includes: Drive-through banking facility for future bank tenant
Employees/Occupants: Approx. 48 (potential for 120)
Gross Square Footage: 26,703 including balconies
Conditioned Space: 24,084
Total Cost: $3,775,000
Cost Per Square Foot: $141.36
Substantial Completion/Occupancy: June 2010
Occupancy: 40% as of July 2010

Notes: This article was published in High Performing Buildings, Fall 2010. Copyright 2010 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. Posted at www.hpbmagazine.org. This article may not be copied and/or distributed electronically or in paper form without permission of ASHRAE. For more information about High Performing Buildings, visit www.hpbmagazine.org.
This difference is significantly less than a typical structure. Looking beyond the energy impacts of a vegetative roof, the designers have reduced storm water runoff, improved water quality, reduced the heat island effect, reduced sound reflection, created wildlife habitat, and improved the aesthetics of the roof. Additionally, the life of the roofing membrane (a typical lifespan in the Houston climate is 10–20 years) has been extended to potentially 50 years because of the protection from UV rays, extreme temperature swings and harmful pollution. Also, according to one study, green roofs increase property values.

Cistern System

The Gulf Freeway building irrigation system has no connection to city potable water. An underground cistern holds approximately 320,000 gallons of water in addition to providing detention for storm events on site. The cistern is a network of 48 in. diameter piping situated below the parking areas. It holds a two-year event (the heaviest rainfall that is predicted to occur every two years, or 4.5 in. in 24 hours), but the discharge rate is equal to or less than the original undeveloped discharge of the site. The cistern system also can supplement the building’s graywater system, if necessary.

Building Envelope

The building envelope is faced on the exterior with portland cement plaster and has vapor barriers and 100% water blown, spray-on, closed-cell foam insulation within a 6 in. frame. All of this provides an assembly with a minimum R-value of 26. In addition, it has the ability to provide R-36 for exterior walls and R-5 for the exterior slab.

Foundation

Slab edge insulation R-value
R-5 (estimated)

Windows

U-value: 0.33
Solar Heat Gain Coefficient (SHGC): 0.15
Visual Transmittance: 70%
UV Transmittance: 0%

Location

Latitude: 29° 36’ 43” N
Orientation: Primary axis: east to west
to achieve 0.001 air changes per hour at natural pressures, effectively eliminating energy losses due to infiltration and exfiltration.

The eastern, western and southern faces have sheltered balconies at each floor, providing effective solar shading of the glazing. The structural framing system is a composite design of steel and reinforced concrete.

The steel is 100% recycled material, and the portland cement contains fly ash. Glazing comprises approximately 36% of the building exterior skin. The 1 in. tinted, insulated glazing has a low-emissivity coating. Ninety percent of the occupied portions of the building have access to daylight.

**Building Systems**

The building has an electric traction, guide-rail-mounted, power unit elevator, requiring only a 6.7 hp motor, no machine room and integral electronic logic controls.

HVAC systems consist of a roof-mounted, air-cooled, non-CFC, variable-load stepping rotary scroll chiller of 100 ton capacity with twin air handlers per floor. They use MERV 13 filtration along with UVC air purification. The air handlers incorporate variable frequency drive motor controls.

The outdoor air is 100% pretreated and prefísed prior to entering the envelope. CO₂ sensors allow for digital monitoring and control systems to maintain a level of no greater than 750 ppm while optimizing indoor conditions and air quality.

**Plumbing**

All plumbing includes low water use fixtures. The graywater system recycles condensate water (roughly 84,000 gallons per year) and water from lavatories and drinking fountains. Then, after treatment and carbonation, the reclaimed water is used in the flushing of toilets and urinals.

The building has the first commercial reclaimed graywater system approved by the city of Houston. The city of Houston has no sanitary sewer service available at the site. (However, the site is immediately adjacent to a major freeway and near other retail, restaurant and multifamily sites.)

The inability to obtain public-sanitary sewer service necessitated on-site treatment through the use of a commercial grade aerobic system that uses the vegetative roof as its spray field. Admittedly, this was a benefit of a vegetative roof that the designers explored before deciding on it. The vegetative roof allows for air-quality benefits, which is a benefit to employees and visitors.

Although shading is typically unnecessary for north-facing windows, the designers added a sun shade device (top) to provide partial shading.

**Lessons Learned**

Each building serves as a learning curve as the designers explore options and alternatives to materials, equipment and methods. The designers have used the same vegetative roof assembly method, including the waterproofing approach and insulation positioning, since the Jacob White building (second building). The pricing for Cheyenne One’s original vegetative roof design varied radically from the manufacturer’s expectations, which prompted the designers to develop their own system.

The most frustrating issue to date has been the graywater systems for the buildings. The architects have found through experience that designing and installing their own systems achieves greater reliability at less cost than packaged systems. The firm continues to design its own systems.

Cities have various approaches for permitting a graywater system. Some governments require little data, while others require significant data submission and variances to receive a permit.

Placing insulation under the roof structure has proved challenging. Evaporative spray foam insulation is used for its insulating and air barrier properties. To provide fire protection, an intumescent coating is placed over the spray foam insulation. However, some jurisdictions also require the addition of fireproofing materials over the intumescent coated insulation.

The architects have developed a new approach that involves covering the insulation in places where it might be exposed to a return air plenum. While this approach may seem more complicated, it is actually cheaper than the previous approach and will be used for future projects.

The green roofs with withstand storms well. Cheyenne One was not damaged by Hurricane Ike. No plant material, soil, pathway stone or rooftop equipment was lost. The 120 mph winds and 11 in. of rain were shrugged off just as if that 15,000 ft² of planted area were at ground level.

If Cheyenne One is the design team incorporated a controlled manufacturing environment for the tenant’s medical device production. Stringent temperature, humidity and air quality requirements were met without adjusting the base building HVAC system design. The client anticipated doubling production staff to meet new projections even with new, efficiently designed workspace and room to expand. As of June 2010, the client had doubled production with without increasing staff. He attributes the productivity to the facility’s more efficient layout and abundant glazing, which gives employees a visual connection with the outdoor environment.
had not anticipated. The spray field is the first approval of such a system by the Texas Commission on Environmental Quality (TCEQ).

**Indoor Air Quality**

Low- to no-volatile organic compounds (VOC) finish materials have been used throughout the core and shell, as required by the tenant’s construction guidelines and manual. Construction materials including steel, aluminum, wood and paper products and plastics were recycled, which was also required by the tenant.

The building is a no-smoking facility and, as stated previously, has MERV 13 level filtration at the air handlers; the outdoor air pretreatment unit plus UVC light helps eliminate airborne bacteria. The janitorial services use environment-friendly cleaning materials in all of the buildings. The Gulf Freeway building has extensive antimicrobial touch surfaces that kill various bacteria.

**B U I L D I N G  O N  E X P E R I E N C E**

The Gulf Freeway Office Building was designed based on the designers’ experience from three previous office buildings that have achieved desired energy efficiency outcomes. The first and third are 48,000 ft² three-story office buildings located in the medical center area of Webster, Texas. Cheyenne One is primarily medical offices in support of the immediately adjacent regional hospital and support facilities. Cheyenne One survived Hurricane Ike with recorded winds of roughly 120 mph and more than 11 in. of rain with no damage or impact to the site, building or vegetative roof. The building has been in operation since late 2006 and is more than 80% occupied.

Cheyenne III is a twin of Cheyenne One, and is home to a single tenant researcher and developer of specialty medical devices. It includes a controlled manufacturing environment encompassing one-third of one floor. Cheyenne III opened in the third quarter of 2008. Jacob White Offices (the second building) is a one-story, 10,001 ft² office building that serves as the headquarters for the owner’s operations. This building in Friendswood, Texas, has been occupied since early 2009. Each building is in the process of LEED certification and ENERGY STAR designation. The lowest ENERGY STAR rating (based on design statements) of the four buildings is 94.

**Parking**

The building has parking for 91 cars including dedicated carpool and low emission vehicle parking, as well as bicycle racks. The site is immediately adjacent to a Metropolitan Transit Authority park and ride lot. Approximately 14% of the site is permeable and sufficient parking is provided at grade. A minimum of 50% of that parking area will be shaded by tree canopy in five years.

**Going Forward**

The architects have taken to heart the American Institute of Architects’ The 2030 Challenge to reduce energy and greenhouse gas emissions by 50%, and then increase the requirement every five years for a final result of carbon neutrality in 2030. Each of the architects’ last

**E V A L U A T I N G  G R E E N  C O S T S  A N D  P A Y B A C K**

The additional premium for Cheyenne One’s sustainable and efficient features was roughly 6%. The subsequent buildings have had less variance as the designers honed their approach. The overall cost variance now is roughly 1%–2%.

The owner of all four buildings estimates that the payback period for the additional cost of the buildings’ green features is approximately four years. The majority of the payback period is due to the elevators.

The cost of a planted in place vegetative roof is approximately $20/ft². A single-ply membrane, insulated cool roof (now required by the city of Houston) costs approximately $5.50 to $8/ft² without insulation. A vegetative roof provides additional green space and on-site detention, and increases the value of the building by roughly 20%, according to the owner’s calculations.

<table>
<thead>
<tr>
<th>Year Opened</th>
<th>Cheyenne One</th>
<th>Jacob White Offices</th>
<th>Cheyenne III</th>
<th>FC Gulf Freeway</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>73.6</td>
<td>21.9</td>
<td>76.3</td>
<td>24*</td>
</tr>
</tbody>
</table>

Energy use intensity (kBtu/ft²·yr)

*Predicted
four major buildings and one new smaller building are all designed with features to meet and exceed the 50% reduction of energy today. The owner of the Gulf Freeway Office Building understands the ultimate benefits for the community and has urged the designers to find other features and technologies to keep ahead of the curve in operating his facilities more efficiently.

Reference

ABOUT THE AUTHOR
Joe Douglas Webb, AIA, is a principal at Webb Architects in Houston.