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Title

California department of education HQ block 225: California's valedictorian

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California's

Valedictorian

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The California Department of Education Headquarters' facade resembles a graduation cap worn proudly on the day of achievement. It symbolizes a building that has mastered the art of sustainability and now serves as an example for green building in California and throughout the country.

The bar was raised high for the building, also known as Block 225, before construction began. The California Department of General Services wanted a green building, and the design-build team set a goal of achieving LEED Gold certification—a relatively new green standard in 1999.

Block 225 is the first California state office building to use an underfloor air-distribution system and is the first design-build office building in the state's history. The integrated approach to design and construction resulted in the building's completion 10 months ahead of schedule. The design-build team and Department of General Services blazed a trail for all future state-developed projects.

The building became only the second LEED Gold building in California as of 2003. It also is thought to have been the world's largest LEED Gold New Construction v. 2.0 state office building at the time.

Further improvements in operations and maintenance of the building led to more distinctions. Block 225 received LEED Platinum Existing Buildings certification in 2006. It is believed to be the world's second largest Platinum-EB building and was only the second building to achieve the certification at the time.

Now the building serves as a teacher, providing sustainability lessons to visiting students and helping them consider how they choose to impact their environment.

Project Purpose/Overview

Block 225 is part of the Capitol Area East End Complex in Sacramento. The Complex involved the construction of five office buildings, along with aboveground and belowground parking. These buildings consolidated two state departments on state-owned land to the east and south of Capitol Park. Block 225 consolidated the headquarters of the Department of Education, which formerly occupied several facilities located throughout Sacramento.

BUILDING AT A GLANCE

Name	California Department of Education Headquarters—Block 225
Location	Sacramento, Calif.
Owner	State of California, Department of General Services
Principal Use	Office
Includes	Non-profit daycare center, underground garage, electric vehicle charging stations, retail
Employees/Occupants	1,350
Gross Square Footage	461,000
Conditioned Space	394,684 ft ² (excluding parking & retail)
Total Cost	\$75 million
Cost Per Square Foot	\$149 (per gross square foot including parking)
Substantial Completion/Occupancy	July 2002
Occupancy	90%
Distinctions/Awards	LEED-NC 2.0 Gold certified in 2003; LEED-EB Platinum certified in 2006; Governor's Environmental and Economic Leadership Awards, Sustainability, State of California EPA, 2003; Design-Build Excellence Award, Public Sector Over \$15 Million, Design-Build Institute of America, 2003

The exterior glass curtainwalls use high performance glazing, and highly articulated cornices and overhangs provide shading. The precast exterior concrete boosts the percentage of local materials used in construction.

Photo © Erhard Fleiffer

BUILDING TEAM

Owner State of California,
Department of General Services

Program Manager 3D/International

Master Architect Johnson Fain Partners

Architect of Record Fentress Architects

Associate Architect
Dreyfuss & Blackford Architects

General Contractor
Hensel Phelps Construction Co.

Mechanical Engineer
Critchfield Mechanical, Inc.

Electrical Engineer Rosendin Electric,
The Engineering Enterprise

Energy Modeler Taylor Engineering

Structural Engineer PK Associates
(Paul Koehler Consulting)

Civil Engineer Nolte

**Environmental & LEED
Consultant** SMWM

Landscape Consultant The HLA Group

Lighting Design Consultant
The Engineering Enterprise

Commissioning SMWM



Photo © Erhard Pfeiffer

The façade of Block 225 resembles a graduation cap. The building houses the California Department of Education headquarters.

Sustainable Design

The design-build team developed 145 strategies for sustainable enhancements, eventually incorporating 110 that provided the best value.

A sustainable design begins with a high performance building envelope. A thermoplastic membrane roofing system is made with 100% recyclable PVC-free rubber and reflects over 70% of solar radiation. It lowers roof temperature to 15°F to 25°F above the ambient temperature and correspondingly lowers cooling loads. Exterior glazing (sized at roughly a 40% window-to-wall ratio), low-e coatings and tinted glass improve thermal performance while reducing glare.

A section of Block 225's penthouse enclosure features a building-integrated photovoltaic system. The 310 photovoltaic panels are integrated into the exterior envelope design and are capable of generating up to 2% of the building's power.

An underfloor air-distribution (UFAD) system conditions floors two to six. In contrast to the conventional grid of overhead diffusers

spaced at relatively large intervals, UFAD systems deliver fresh air through a larger number of floor diffusers strategically placed near each occupant. This system improves thermal comfort while saving energy and generating less demand on building operations and fewer maintenance calls.

A raised floor system forms the low pressure underfloor plenum, which supplies air to the floor diffusers. The raised floor system also serves as a cable management raceway and allows for easy maintenance on underfloor fan-coil units. The ease of repositioning floor diffusers reduces life-cycle costs associated with maintenance and reconfiguration of HVAC and electrical services. Block 225 took advantage of these potential savings when the building was reconfigured in 2003 to accommodate 250 additional workers.

Improved energy efficiency was another goal of UFAD. In mild western U.S. climates such as Sacramento, UFAD energy savings are usually associated with

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A photovoltaic system is integrated into Block 225's mechanical penthouse enclosure. The 310 photovoltaic panels are capable of generating up to 2% of the building's power.

INSIDE BLOCK 225'S UFAD SYSTEM

Plenum Layout

For UFAD floors, conditioned air is distributed through a series of air highways—fabricated ducts consisting of the top of the slab, underside of floor panels, and two sheet metal sides—as shown by red shading in Figure 1. Variable volume damper spin-in units are mounted along the sides of the air highways to provide multiple plenum inlet locations across the large (50,000 ft²) floor plate.

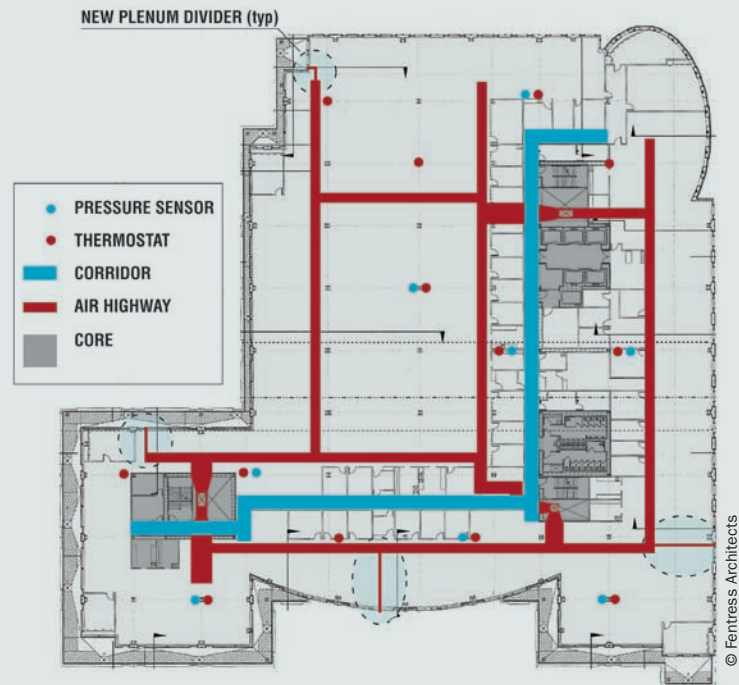
Figure 1 shows how the system of central corridors and air highways divides the plenum into distinct control zones. Each zone has at least one pressure sensor in the plenum and one thermostat in the conditioned space above. Underfloor variable speed fan-coil units at the building skin are ducted to linear bar grille diffusers located on the windowsills, as shown in Figure 2. These units draw supply air from the plenum and deliver it as needed during cooling operation. They provide heat from hot-water coils during heating.

Controls

Interior zones are controlled using a cascaded control loop. The underfloor pressure setpoint is reset based on (average) interior zone thermostat deviation from setpoint. Similar to interior zones, plenum pressure in perimeter zones is maintained by the adjustable spin-in dampers on the air highways serving that area based on a nearby interior zone thermostat.

Signals from column-mounted thermostats at the exterior walls control the variable speed perimeter zone fan-coil units, which operate independently of the plenum pressure setpoint. This arrangement allows the fan coil units to meet high building skin loads even when plenum pressures are reduced due to low interior loads.

FIGURE 1



Four plenum dividers were installed on each floor, as shown here for the fourth floor, creating four separate, more manageable control zones for the UFAD.

FIGURE 2



At the perimeter, underfloor variable speed fan-coil units are ducted to linear bar grille diffusers located on the window sills. These units draw supply air from the plenum as needed during cooling operation and provide heat from hot water coils during heating.

KEY SUSTAINABLE FEATURES

Water Conservation

- 36% reduction of potable water consumption
- 67% reduction in irrigation water

Recycled materials

- 95% of construction waste diverted from landfill
- 100% of scrap/waste metal was recycled
- At least 25% of the building includes recycled materials
- Up to 60% recycled content used in structural systems
- 53% recycled content in carpets
- 82% recycled content in acoustical ceiling tiles
- More than 30% recycled content in 50,000 pounds of acoustical insulation, manufactured formaldehyde-free

Daylighting

- Daylighting and views available for 90% of the space
- Perimeter dimming controls when daylight and electrical loads are at peak
- Task lighting at workstations operated by motion sensor
- Low-e glazing

Individual Controls

- Occupant controlled temperature, ventilation and lighting

Other Features

- Up to 2% of electricity use generated on-site for Block 225 (photovoltaics produce 9.3 kW ac)
- “Cool” roof (thermoplastic membrane)
- Integrated Pest Management—Eco-friendly landscape design (leading example became a statewide practice in California)
- 64% reduction in parking, with up to 53% being alternate transit

The Board Room and the rest of the ground floor is served by an overhead variable-air-volume system.



increased economizer use. Higher supply air temperatures and lower fan energy use due to decreased static pressure through the underfloor plenum contribute to energy savings.

In practice, measuring only the UFAD system's energy performance is difficult, especially in Block 225, which uses multiple systems (a standard overhead variable-air-volume system was installed on the ground floor) and many energy-saving strategies. Nevertheless, the energy performance of Block 225 (see *Energy Use*) has been impressive.

Ninety percent of the interior spaces offer natural daylighting and outside views, further contributing to increased user comfort and reduced energy costs. Operable and task lighting (operated by motion sensors) are located at workstations, while perimeter dimming is activated when daylight and electrical loads are at their peak.

Occupancy sensors are used in all closed offices and utility rooms. Monitored electricity use (during occupied hours from September 2007 to August 2008) confirmed these reduced internal loads with average

overhead lighting equal to 0.38 W/ft² and plug loads (equipment and task lighting) equal to 0.60 W/ft².

The design-build team worked with manufacturers to improve their processes and reduce volatile organic compound levels on products previously considered indoor eco-friendly. New methodologies relating to materials and testing were established to minimize the impact of source emissions on the interior environment, offering innovative advancements for industry-wide use.



An open floor office layout and raised ceiling heights improve daylighting, while sensor-activated perimeter lighting reduces energy use. Floor diffusers are strategically placed near each occupant.

ENERGY USE

The overall building electric and gas energy use for Block 225 is shown in Figure 3. Although a variation exists between years, the use is similar.

ENERGY STAR ratings for Block 225 have been tracked through EPA's Portfolio Manager since 2003. The May 2009 report is shown in Figure 4. The ENERGY STAR rating of 98 and the energy use

intensity (EUI) of 43 kBtu/ft²·yr demonstrate exceptionally low energy consumption and prove that the building is operating efficiently.

Its energy use is significantly lower than required for an ENERGY STAR label. The EUI has improved by about 15%, most likely because of extensive commissioning conducted since occupancy.

FIGURE 3

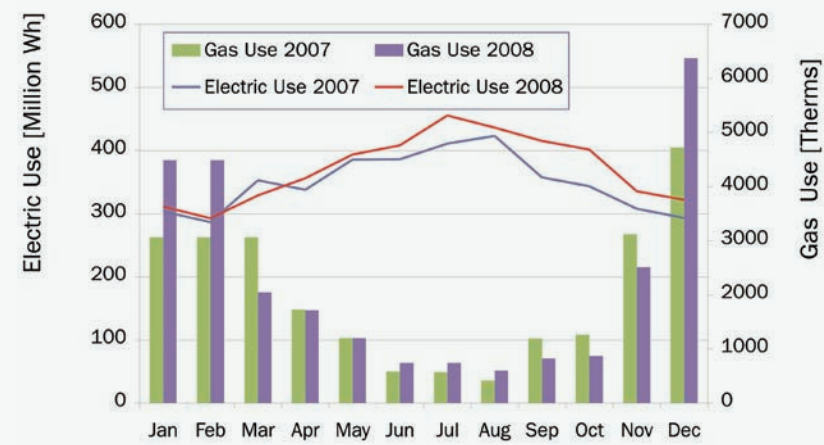


FIGURE 4

Performance Metrics	2009 (Ending Date 03/31/2009)	Baseline (Ending Date 12/31/2003)	ENERGY STAR Label	National Average
ENERGY STAR Rating	98	97	75	50
Energy Use Intensity				
Site (kBtu/ft ²)	43	51	83	110
Source (kBtu/ft ²)	130	144	247	330
Energy Cost				
\$/yr	\$466,751	\$408,215	\$886,656	\$1,184,392
\$/ft ² ·yr	\$1.11	\$0.97	\$2.11	\$2.82
Greenhouse Gas Emissions				
Carbon Dioxide (Mt/yr)	1,649	1,875	3,132	4,184
Carbon Dioxide (kg/ft ² ·yr)	4	4	8	10

ENERGY AT A GLANCE

Energy Use Intensity (Site) 43.52 kBtu/ft²

Natural Gas 6.6 kBtu/ft²

Electricity 36.9 kBtu/ft²

Renewable Energy 0.08 kBtu/ft²

Annual Source Energy 130.1 kBtu/ft²

Annual Energy Cost Index (ECI)
1.11 \$/ft²·yr

Savings vs. Standard 90.1–2004

Design Building 43%

ENERGY STAR Rating 98

BUILDING ENVELOPE

(MOSTLY BASED ON MODEL)

Roof

Type White Roof—single-ply elastomeric polyurethane roofing

Overall R-value 30

Reflectivity Albedo reflectance of 0.5 minimum

Walls

Type Architectural precast concrete, metal panels, stone, curtainwall

Overall R-value 12

Glazing percentage 30,546 ft² of 72,773 total ft² = 42% glass glazing

Basement/Foundation

Type Shotcrete and cast-in-place concrete; non-occupied basement

Windows

U-value

GL-1: 0.29 Btu/h winter, 0.3 summer;
GL-2: 1.09 Btu/h winter, 1.13 summer

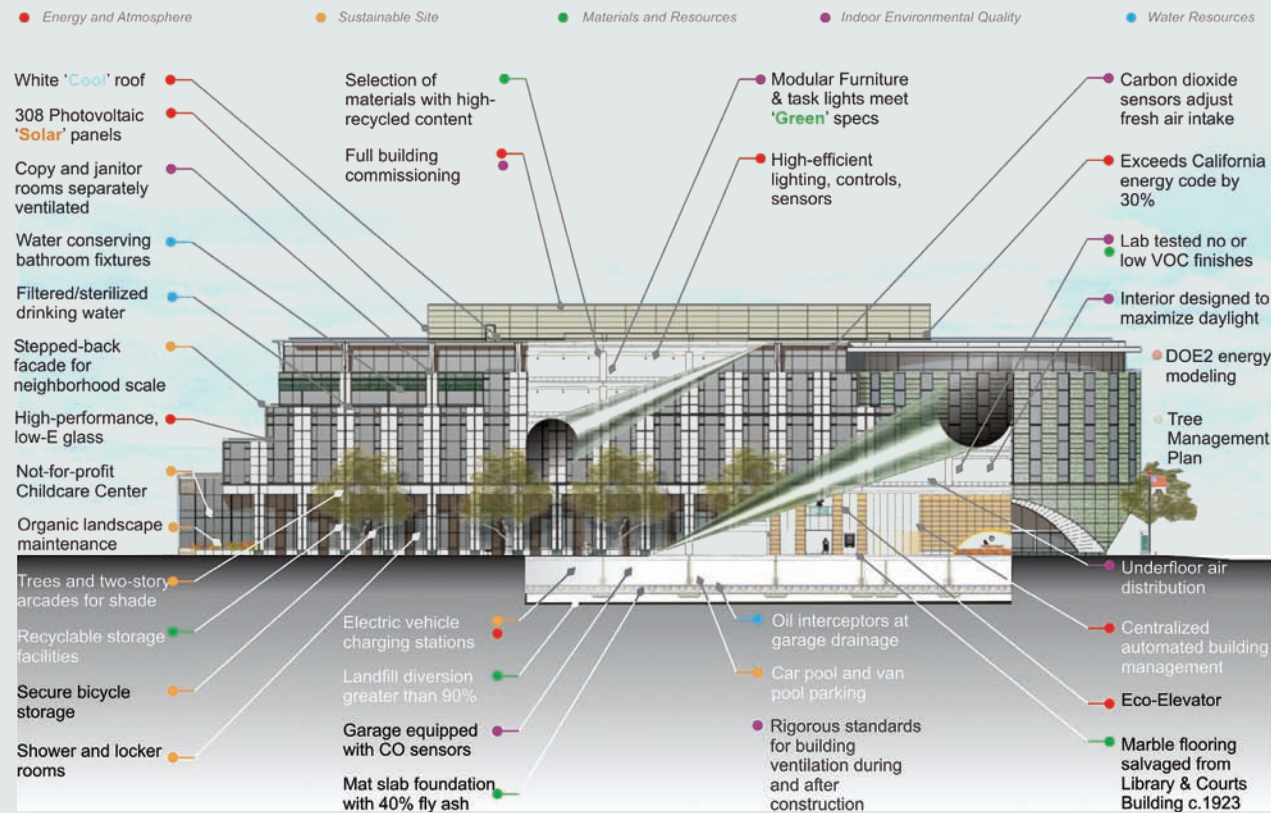
Solar Heat Gain Coefficient (SHGC) 0.23

Location

Latitude 38° 34' 25.10" N (121° 29' 20.89" W)

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SUSTAINABLE FEATURES



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SOLAR SECTION

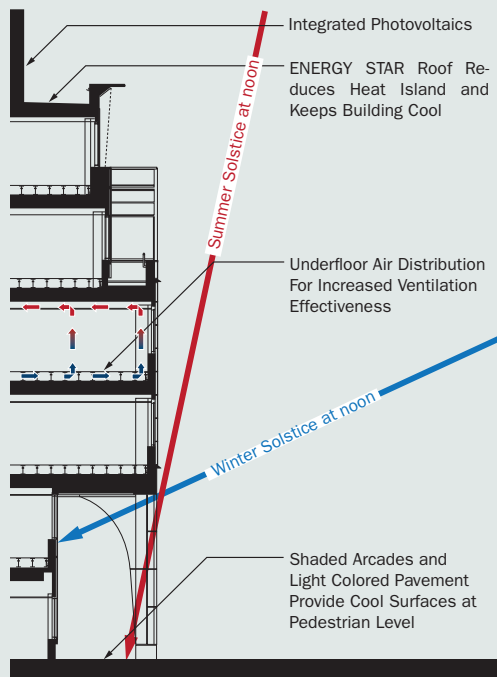
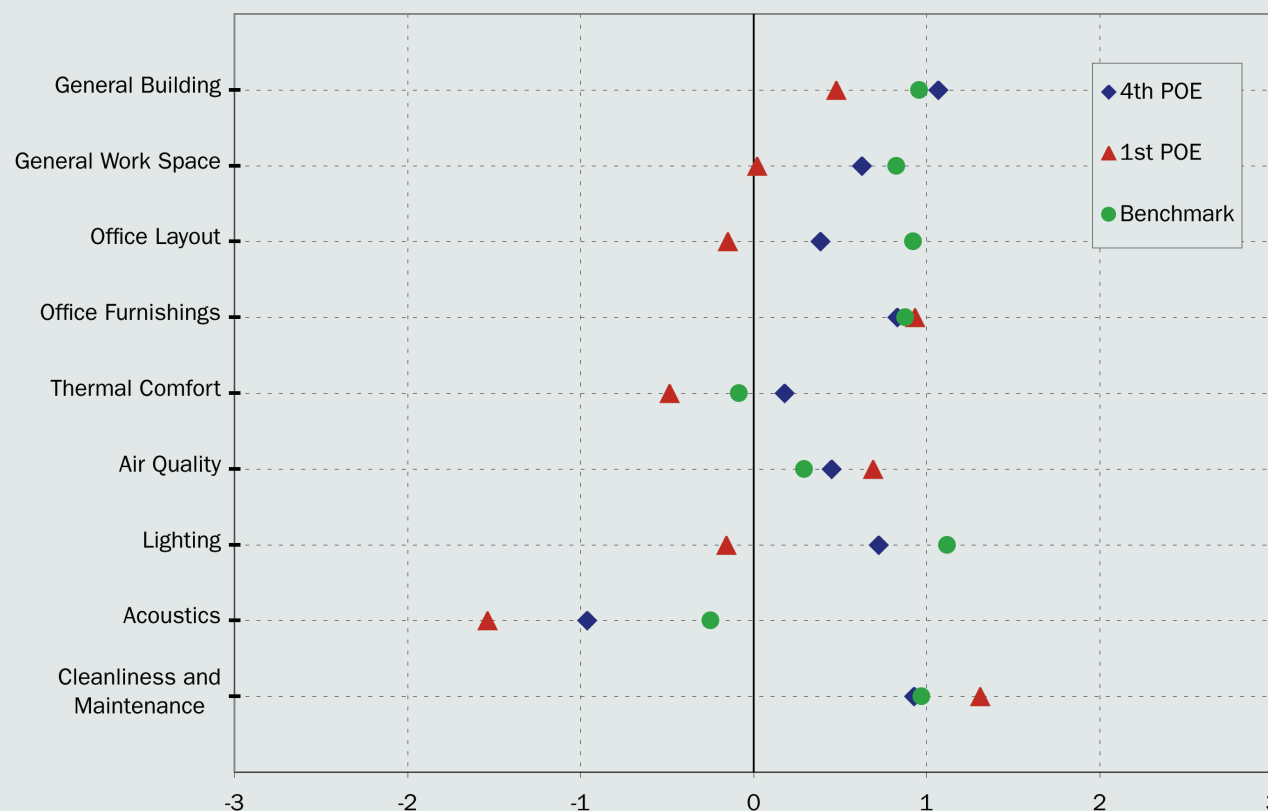


Photo © Erhard Pfeiffer

Articulated columns support a covered arcade that shades visitors and the two-story glass curtainwall.

FIGURE 5 POST-OCCUPANCY EVALUATION



The first post-occupancy survey was conducted in January and February 2003 (N=500).
The fourth survey was conducted in October 2007 (N=650).
The benchmark data includes 430 buildings (N=47,929).

OCCUPANT SATISFACTION

A Web-based satisfaction survey administered to Block 225 occupants provides additional information on actual building performance. The survey addresses occupant satisfaction for seven environmental categories, as well as two questions on general satisfaction with the building and personal work space. The survey has been administered to nearly 48,000 occupants in 430 buildings of all types and sizes, creating a large benchmark database. Four post-occupancy evaluation (POE) surveys have been completed since the building was occupied in July 2002. Figure 5 compares average occupant satisfaction ratings for the most recent POE (October

2007) to those of the first POE (January/February 2003) and the large benchmark database. Response rates for both Block 225 surveys were close to 50% and were a fair, representative sample. The survey results are generally positive, considering that Block 225 is a large open plan office building. The results for the fourth POE indicate that occupant satisfaction has increased significantly in most categories since the first POE. Three categories (general building, thermal comfort, air quality) were likely influenced by the existence of the UFAD system and the recommissioning and tuning up of the building's HVAC operation. Floor diffus-

ers give occupants a sense of personal control while increasing air movement and available fresh air. All categories were rated above zero except acoustic quality in the October 2007 survey. The acoustic quality rating is not surprising for a large open plan cubicle layout and is a contributing factor to the average or below average ratings for general workspace, office layout, and office furnishings. Improvements to the task lighting resulted in a large increase in satisfaction with lighting quality. The decline in satisfaction with cleanliness/maintenance and, to some extent, air quality since the first POE is likely due to the building's increasing age.

SUSTAINABLE DESIGN COSTS AND SAVINGS

Block 225 was procured as design-build project with a stipulated sum, or best value delivery, of \$75 million. The design and construction teams, using an integrated design approach and reinvesting over a half million dollars from a shortened construction schedule, were able to provide additional sustainable features within the budget at no additional cost.

The cost of the sustainable features was estimated at roughly \$1.2 million. The costs include additional design fees, materials testing, UFAD and application fees for LEED Gold. The design and construction team also researched and applied for grants to fund additional sustainable features, including the 310 building integrated solar panels, recycled rubberized asphalt street paving, and the daycare playground surface made from recycled sneakers.

The integrated design approach made a significant impact on the design production and construction schedule and costs. The contractor and subcontractors were on board early in the design process. This allowed the architect to work directly with the exterior envelope subcontractors to develop the shop drawings directly from the design intent documents. This streamlined the design document development and shop drawing submittal and review, significantly shortening the process.

The energy model predicted that the sustainable features would yield an average savings of \$185,000 a year, resulting in an estimated payback period of less than seven years. However, the design team has been unable to verify the accuracy of the modeled energy cost savings. The building has been in operation since 2002, meaning that in theory, the principal investment has been recouped. The state should continue reaping savings each year from reduced operational costs.

Findings from the UFAD Field Study of Sacramento Capitol Area East End Complex will be posted at <http://www.cbe.berkeley.edu/research/briefs-eastend.htm>.

Landscape designers for Pocket Park selected plant species that attract beneficial insects and animals, providing natural pest control.



Photo © Erhard Pfeiffer



Photo © Erhard Pfeiffer

The patterned marble used for the stone floors in the main lobby and elevator lobby was recycled and reused from the original Sacramento Library and Courts Building, circa 1923.

A LEED innovation credit was achieved through a new Green Education Outreach Program. The project team created an educational brochure describing the building's sustainable features, which is distributed to schoolchildren and tourists. R&D of sustainable design and

materials provided the basis for the California Best Practices Manual, which is used statewide as a guide for green building in California. The team also developed Section 01350 of the manual, "Special Environmental Conditions," for managing the LEED, design and construction processes for sustainability.

Block 225's high performing envelope, innovative design features and fully integrated design resulted in a building that outperformed California Title 24-98 energy codes by 43% (based on simulation capabilities in 2002), saving an estimated \$185,000 a year in energy costs alone. It reduced potable water consumption by 36%, used recycled content in at least 25% of building materials, and reduced air, light and noise pollution. The exceptional effort to maximize use of low-emitting materials, paired with improved ventilation effectiveness provided by the UFAD system, produced a healthier indoor environment.

As a fast-track design-build project, Block 225 finished 10 months ahead of schedule by using innovative techniques in design production and construction. The design-build team delivered the best value by eliminating 10 months of construction costs (general conditions and overhead costs) and reinvesting the savings — over a half million dollars — into sustainable features.

These efforts were rewarded with a LEED Gold certification — the first LEED certified state office building in California.

LESSONS LEARNED

Thermal decay Performance measurements during the first few years of occupancy revealed larger than expected temperature gain (thermal decay) in the supply air as it traveled through the underfloor plenum in this 50,000 ft² floor plate building. The entire outer ring of the building's perimeter space was a single open, connected plenum zone at the time. This increased travel distances of supply air before delivery, thereby likely increasing thermal decay.

The control of thermal decay was improved by dividing the plenum into smaller zones using plenum dividers or other means (Figure 1), particularly along different exposures of the perimeter zone. This retrofit resulted in higher occupant satisfaction.

Reset strategies Since heating is provided only in the perimeter zones, supply air temperature reset strategies must be carefully considered in plenum zones serving both interior and perimeter spaces. During periods of peak cooling demand at the perimeter, reducing the supply air temperature entering the plenum (to address perimeter loads) must be traded off against overcooling occupants in the interior.

Perimeter sill grilles Perimeter sill grilles are architecturally attractive. However, installing perimeter diffusers at floor level reduces the vertical projection (mixing) of supply air in the room, improving stratification and energy performance in the perimeter zones.



Photo © Erhard Pfeiffer

Artist commissioned works in the lobbies integrate public art and architecture.

Conclusion

The aggressive approach toward Block 225's green design resulted in energy savings, reduced the building's impact on the environment and helped establish sustainable building practices for the state of California. Continued maintenance and adjustments to the mechanical systems will help ensure a century of efficient operations. ●

ABOUT THE AUTHORS

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