SPREADING THE WORD

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The library for California State University, Monterey Bay was housed in a small former military building. But, the campus needed a modern facility with virtual and print resources, and spaces for collaboration and learning. The three-story Tanimura and Antle Family Memorial Library, which opened in 2008, is now the academic hub for the 12-year-old campus. The library stands out from its utilitarian surroundings with a glass tower that washes the central atrium in daylight, one of many design elements that reduces the building's energy use.

The 136,000 ft^2 facility includes book stacks, study nooks, 350 computer stations, a main telecom room, archive room, a 200-seat auditorium, a 100-seat classroom, five small classrooms, 14 collaborative study rooms, offices, and a ground floor café and computer lab. The open 2,200 ft^2 reading room with adjoining catering kitchen and balcony can be used for community and campus events, special lectures, and exhibitions.

The building also serves the community as a public library, giving local residents the ability to use the library's books and computers, although priority is given to students, faculty and staff.

Envelope and Materials

The library's architectural features promote energy efficiency and cost savings. The building's north-facing orientation provides plenty of ambient daylight to the interior reading areas and study spaces. The high performance glazing's low-e coating, 70% visible light transmittance and a 0.37 solar heat gain coefficient result in a light-to-solar gain ratio of 1.89 and an overall U-value of 0.29 in winter nighttime conditions.

Opposite **The library's metal framed walls are finished with cement plaster, stucco and metal siding. Exterior aluminum shading and insulated low-e glass minimize solar heat gain and maximize visible light transmission.**

Above right **The main circulation area features colorful terrazzo finishes. The building is served by an underfloor air-distribution system, which offers several advantages compared to an overhead mechanical system; it reduces energy use, gives occupants increased control of their environment via floor diffusers, and provides improved air quality.**

The three-story axial atrium is open to the stack areas and serves as a smoke exhaust system. Its ends are fully glazed, and an arched roof that creates a light scoop brings daylight beyond the perimeter zones and into the building's interior.

The sloped roof and high north-facing windows are classic methods of daylight harvesting, allowing for primarily diffuse daylight to penetrate more deeply into the space than would have been possible with a flat roof and lower window height.

An exterior shading system further eliminates solar glare from the book stacks and occupied zones, and relieves the east and west façades of increased solar heat gain.

BUILDING AT A GLANCE

Name The Tanimura & Antle Family Memorial Library

Location California State University, Monterey Bay, Calif. (7 miles NE of Monterey, Calif.)

Owner California State University

Principal Use Library
Includes Library, book stacks, support area, computer rooms, private studies, conference rooms, classrooms, offices, and café

Occupancy 100%

Gross Square Footage 136,000

Distinctions/Awards LEED-NC Silver

Total Cost $68 million
Cost Per Square Foot $500

Substantial Completion/Occupancy
December 2008

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The concrete structure with exposed walls and beams provides thermal mass, which minimizes heating and cooling loads by reducing interior temperature fluctuations.

The shading system still allows for expansive exterior views, which include Monterey Bay and the Salinas Valley.

Building materials were selected to minimize environmental impact while ensuring good indoor air quality. Twenty-one percent of all building materials are made of recycled content or regional materials, or both. Fly ash, a by-product of coal power plants, replaces 50% of the cement in the building's huge concrete matt slab. Since each pound of cement releases one pound of CO_2 when it is manufactured, this one component reduces greenhouse gas emissions by more than one million pounds.

Eighty-seven percent of roof surfaces are constructed with materials with high solar reflectance index values. Ninety-three percent of nonroof impervious surfaces on the site are paved with reflective materials and open grid pavement, significantly reducing the heat island effect.

Energy-Saving Strategies

The mechanical systems provide the building with chilled water using high-efficiency VFD chillers, which operate at 0.28 kW/ton. The cooling towers have a 5°F approach with 10 hp premium efficiency motors and VFDs.

Based on the energy model of the building, the design exceeds California's Title 24-2005 energy code by 23.1% and results in an energy cost savings of 21.8% below ASHRAE Standard 90.1-2004. A

ENERGY AT A GLANCE

Annual Energy Use Intensity (EUI) (Site) 46.18 kBtu/ft^2
- Natural Gas 15.69 kBtu/ft^2
- Electricity (From Grid) 30.49 kBtu/ft^2

Annual Source Energy 118 kBtu/ft^2

Annual Energy Cost Index (ECI) $1.95/ft^2

Savings vs. Standard 90.1-2004 Design Building 21.8%

Heating Degree Days (base 65˚F) 3,343

Cooling Degree Days (base 65˚F) 80

Average Operating Hours per Week
- Library 40–90 hr/week, depending on academic schedule
- Café About 73 hr/week

WATER AT A GLANCE

Annual Water Use
- Site and Building 212,601 gallons
- Building Only 18,701 gallon

BUILDING ENVELOPE

Roof
Type Built-up roof over tapered insulation
Overall R-value R-30

Walls
Type Metal framed walls with batt insulation; outer finishing is cement plaster, stucco and metal siding
Overall R-value R-19
Glazing Percentage 50%

Basement/Foundation
Slab Edge Insulation R-value R-19

Windows
Effective U-factor for Assembly 0.29
Solar Heat Gain Coefficient (SHGC) 0.37
Visual Transmittance 70%

Location
Latitude 36.64
Orientation Faces north

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Above **The library provides a variety of study and research areas, including this bright and airy space on the second floor and classrooms, collaborative study rooms, a computer lab and a café.**

Below right **Native vegetation and a drip irrigation system that responds to weather conditions reduces water use. Reflective materials and open grid pavement also contribute to the project's sustainability.**

review of actual metered energy use versus the predicted energy use shows that the building is performing nearly 28% better than expected, at about 45 kBtu/ft^2· yr from August 2010–July 2011 (*Figures 1* and *2*).

The design team reduced the overall building height by 11 ft (from 66 ft 6 in. to 55 ft 6 in.) by locating the mechanical system beneath raised floors, saving space and cost on ceilings, ducting and controls. The underfloor air-distribution (UFAD) system delivers air to the occupied zones of the building and is supplied by interior and penthouse-enclosed air handlers. The design day supply air temperature from the UFAD system is 65°F and is maintained by mixing outside air with return air in an economizer mode when the ambient temperature is below 65°F, or by cooling the air supply with chilled water when the ambient temperature is above 65°F.

Temperature control for thermal comfort is achieved through VAV controls and hot water reheat in the zones. Excess air admitted from outside, for economizer cooling or to maintain minimum ventilation rates, is exhausted from the building via the atrium with three penthouse exhaust fans that modulate their VFDs to maintain constant building pressure.

A chiller plant in the library penthouse supplies chilled water for the building, and is comprised of two 190 ton centrifugal chillers, associated cooling water pumps, chilled water pumps and cooling towers. All equipment is penthouse-enclosed rather than roof-mounted because of the corrosive, foggy coastal environment at Monterey Bay.

LIBRARY FUNDING

The state of California funded $56 million of the project's $68 million cost; the remainder was from private donations. The largest private donation was given by the Tanimura and Antle family, which operates a Salinas, Calif.-based produce company that farms more than 30,000 acres.

CAL STATE, MONTEREY BAY'S COMMITMENT TO SUSTAINABILITY

Cal State, Monterey Bay campus sustainability efforts—and the deep integration of this core value into its curriculum—enabled the university to attain a gold rating in STARS, which is a self-reported sustainability tracking system administered by AASHE, the Association for the Advancement of Sustainability in Higher Education. It became the first California State University and only the second public university in California to receive that distinction. Next, it is setting its sights on the highest rating, platinum, which no school has yet attained.

—Cal State, Monterey Bay President Dianne F. Harrison

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An underfloor air-distribution system with linear grilles efficiently and effectively distributes air to occupied zones including this open reading area on the building's south side.

FIGURE 1 **ACTUAL ELECTRICITY USE VS. SIMULATED**

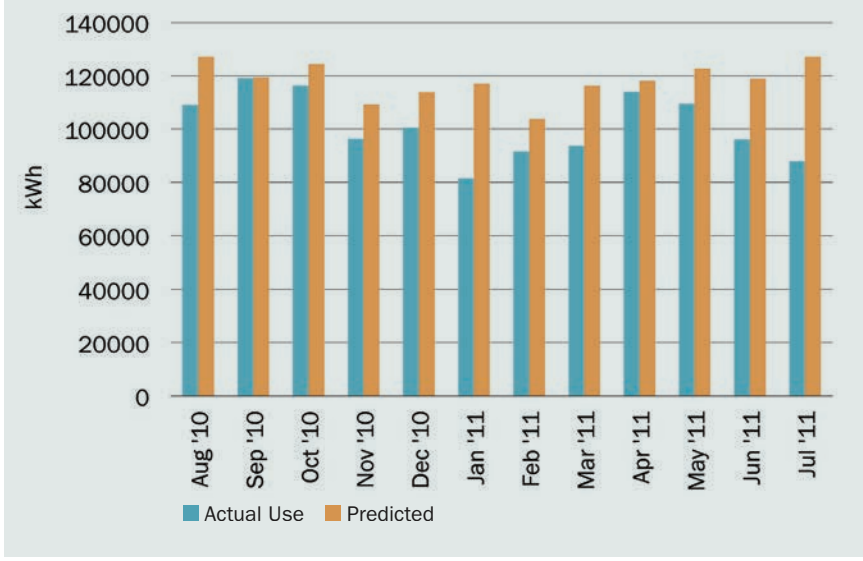
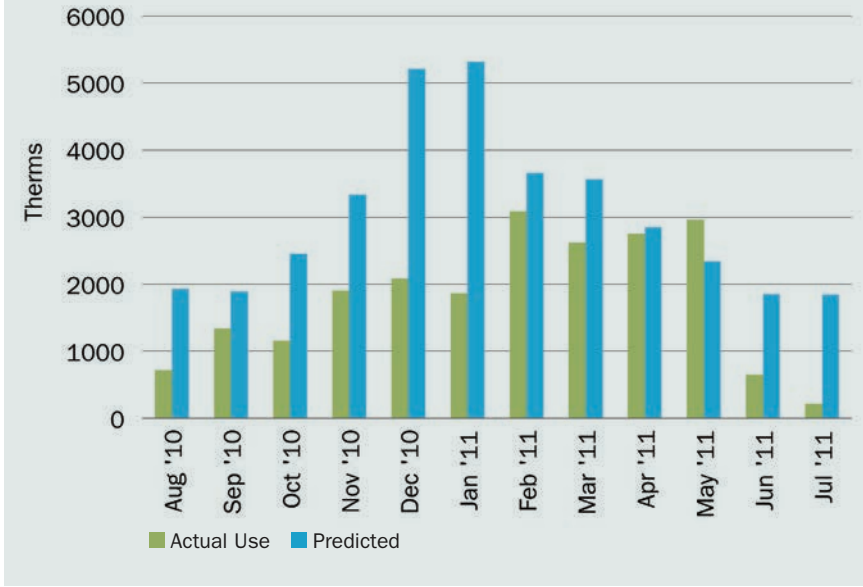


FIGURE 2 **ACTUAL NATURAL GAS USE VS. PREDICTED**



Unlike overhead mechanical systems, the library's underfloor air approach allows for controlled thermal stratification, higher supply air temperatures, and reduced static pressures in the underfloor plenum, all resulting in an overall reduction in energy consumption. Due to the 65°F supply air temperature for the UFAD system, the reheat load is much lower than that of an overhead system, which would require heating the supply air in the winter from 55°F instead of 65°F. Further, the mild Monterey Bay climate helps to maximize the outside air economizer's efficiency, due to the combination of relatively low outdoor ambient dry-bulb temperatures and the elevated supply air temperatures.

Multiple designs and strategies contribute to the library's carbon footprint reduction. For example, due to the UFAD system's absence of overhead ducting, the floor-to-floor height was reduced and the project saved on construction materials and transportation emissions.

Highly efficient mechanical equipment and envelope properties led to a 23.1% reduction in energy consumption below the California Title 24-2005 energy code. Based on the annual energy use intensity totals, the library emits an average of 3.76 tons of $CO_2/ft^2 \cdot yr$, a reduction of 1.08 tons below the proposed building's emissions.

UFAD systems also provide several advantages in indoor air quality and thermal comfort. Occupants have increased control of their

Above **A social and learning epicenter, the library is also the largest and most energy-efficient building on the California State University Monterey Bay campus with an annual EUI of 46.18 kBtu/ft².**

Left **Daylit zones along the window walls provide views to the surrounding landscape and beyond to Monterey Bay and the Salinas Valley. Photosensors and occupancy sensors control interior lighting in conjunction with multilevel switches and dimmers.**

environments and thermal comfort with floor diffusers in each workstation that can be individually adjusted. The systems also deliver clean, filtered air nearer to the occupant and more efficiently remove contaminants from the occupied zone, leading to improved air quality.

The outdoor air economizer allows the return air temperature to be higher (80°F as opposed to the 75°F baseline design), which results in the building being supplied with 100% outside air for more hours throughout the year. The building's three-story atrium is used as a relief air path. The provision of operable windows for smoke control also affords the opportunity to naturally ventilate the building in the event of a power outage.

Lighting

Energy-efficient fluorescent sources throughout the building meet strict energy codes and maintenance criteria. The lighting control panel (LCP) system is comprised of a relay panel with an integral astronomic time clock and a remote-mounted photocell, and can turn artificial lighting in daylit spaces on and off.

Interior lighting also is controlled by occupancy sensors in conjunction with multilevel switches and dimmers, which provide a high level of individual control in the stack areas and the atrium. Occupancy controls are not used in the stack areas during operating hours to prevent distraction. The LCP controls all exterior lighting and can be programmed to maintain more than one schedule at a time.

KEY SUSTAINABLE FEATURES

Water Conservation Waterless urinals and sensor activated, low-flow lavatory faucets. Fixtures save 46.5% below the LEED baseline.

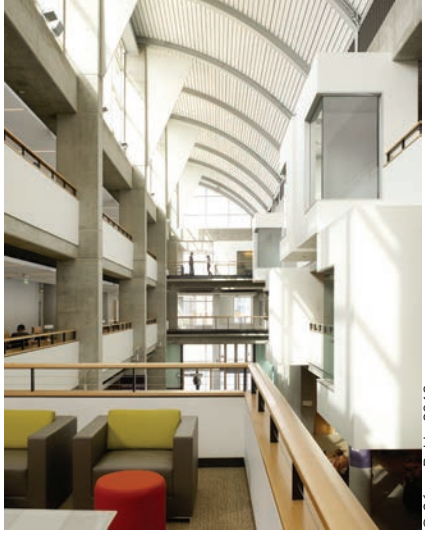
Recycled Materials Concrete, masonry, insulation, glazing, structural steel.

Daylighting Three-story glass-enclosed axial atrium. Fixed exterior aluminum shades and automated internal roller shades control light and glare.

Individual Controls Occupancy lighting control and individual floor diffuser for every workstation.

Transportation Mitigation Strategies Nearby bus stop.

HVAC Whole building underfloor air-distribution system.



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A sweeping three-story atrium brings daylight deep into the building. High north-facing windows and an arched roof create a light scoop, which allows primarily diffuse daylight to penetrate the space more deeply than what would have been possible with a flat roof and lower window height.

Water Conservation

The building's design recognizes that water is a precious commodity in the Monterey region. Ninety percent of the storm water from the building's roof is directed into water gardens and underground perforated tanks where it can return to the aquifer. All plants are native or adapted species with relatively low water needs

The efficient irrigation strategy uses advanced controllers that respond to current weather conditions. These landscaping strategies, along with a drip irrigation system, have reduced landscape water use by 82% from LEED's baseline case.

Efficient restroom fixtures, including waterless urinals, have reduced the building's water use by 46.5% below LEED's baseline. Implementation of the 24-hour free cooling system (see Free Cooling Mode) also reduces water use by the cooling towers.

Operating Costs and Savings

Analysis of the library's utility bills shows that the building is performing better than predicted, saving 16.3% of the total proposed cost, or $52,528 per year. Post-occupancy implementation of the 24-hour free cooling system only required changes to the computerized building management system (BMS) sequences.

Operating at a full load efficiency of 0.29 kW/ton, the dual compressor, magnetic bearing chillers are extremely energy efficient. A built-in VFD modulates the compressor speed in response to the library's changing loads and is designed for maximum part-load efficiency. With a nonstandard part-load value of 0.28 kW/ton, the chiller efficiency peaks at 70% load with 0.25 kW/ton, and is only 0.29 kW/ton as low as 40% load.

The chillers enable the building to save 24 kBtu/ft^2 · yr of predicted source energy use, a significant portion of the total energy savings. The project's energy savings resulted in a PG&E Savings by Design incentive of $134,000.

Reduced floor-to-floor heights from the underfloor air-distribution system resulted in fewer construction

BOOT CAMP TO SCHOOL

Cal State, Monterey Bay grew out of Fort Ord, a decommisioned Army base with a rich history going back to 1917.

Throughout the '50s, '60s and '70s, Fort Ord was a major location for basic training, reaching its heyday during the Vietnam War. Celebrities such as Jerry Garcia and Clint Eastwood completed boot camp here.

In all, more that 1.5 million men and women received basic training at Fort Ord.

When Congress decided to shut down Fort Ord, the local community proposed the base be converted into a university. In June 1994, that plan was approved and Cal State, Monterey Bay began.

—Cal State, Monterey Bay, www.csumb.edu

BUILDING TEAM

Building Owner/Representative
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Free Cooling Mode Project Mike Lerch, Associate Director for Facility Services and Operations at California State University, Monterey Bay

LESSONS LEARNED

One major challenge was keeping the underfloor air delivery system airtight. For raised floor systems, air leakage is a major concern, especially from the joints between floor tiles, electrical floor boxes and interfaces with structure or walls. To reduce leakage, a gasket was placed between the floor tiles, and electrical floor boxes were sealed. All interface locations were meticulously sealed. The use of carpet tile also helped reduce air leakage.

Research by the Center for the Built Environment (CBE) has shown that a significant amount of heat transfer and temperature variation can occur in the underfloor air plenum. This occurs due to radiant heat transfer between the floor and the ceiling, and conduction through the slab. Insulating the air highways reduced the distance that air travels in an uninsulated space.

Ongoing post-occupancy evaluation of the performance of the building is very important. As a result of the evaluation of this building, it was identified that the 24-hour loads were significantly lower than predicted, causing the chiller plant to operate less efficiently than possible. By creatively modifying the sequences of operation, free cooling for the 24/7 rooms has been successfully achieved, allowing the chiller plant to operate for significantly fewer hours at more efficient conditions.

materials and lower HVAC duct costs. The change from a steel structure with an overhead mechanical system, to a concrete structure with UFAD system resulted in an overall savings of $5/ft^2.

Free Cooling Mode

Building operations were evaluated in 2010 and resulted in an energy retrofit and study called free cooling mode[1] by Cal State, Monterey Bay, leading to significant energy savings. Soon after building start-up in 2009, it was noted that any time the outside air temperature was less than 65°F, the main air handlers supplying the underfloor system placed no load on the chiller plant. The only demand was from the equipment room fan-coil units.

The loads for these fan-coil units are significantly less than was anticipated by the users and design team, only 5 tons, instead of the expected 27 tons, or 18% of the design load. Low-load operation had been foreseen in the building design, and the chiller plant had been specified to be able to operate at very low loads with hot gas bypass, but operating this low was not ideal.

Due to the mild coastal climate of Monterey Bay, the outside air temperature is above 65°F for only approximately 1,222 hours per year. The retrofit project takes advantage of the building air handlers' economizer mode, greatly reducing hours of operation for the building chiller plant.

The modification reduced chiller plant hours of operation from 8,760 hours per year to an estimated 1,222 hours per year, saving 243,647 kWh/yr of electricity. Project implementation was simple and only required changes to the computerized building management system (BMS) sequences.

In the new mode of operation, the BMS turns off the chillers, cooling water pumps and cooling tower fans anytime the outside air temperature is below 65°F, but keeps the chilled water pumps operating and partially opens the chilled water valve at each operating air handler. The chilled water circulating through the air-handling unit (AHU) coils rejects heat from the equipment rooms.

At lower ambient temperatures, increasing the proportion of outside air can increase the equipment heat rejection by using more chilled water "preheat." If more heat rejection is needed, additional units can be brought online. ●

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Above **Sustainable building materials are used both indoors and outdoors. Twenty-one percent of all materials are made of recycled content or regional materials, or both.**

Below **The cafeteria on the library's ground floor gives library users convenient access to coffee, tea, smoothies and a grab-and-go menu including sandwiches, salads and microwaveable meals.**

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References

1. "Best Practices Case Studies 2011, CSU Monterey Bay, Tanimura & Antle Memorial Library Retrofit." Green Building Research Center, University of California, Berkeley. http://tinyurl.com/free-cooling.

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