

## **A Stealth Green Building**

*By Marc Rosenbaum*

Oakes Hall is a 23,500-square-foot classroom building designed for Vermont Law School, the nation's leading environmental law school. The building houses a student lounge and nine classrooms, ranging in size from three 25-seat rooms to three 100-seat ones. Goals for the building were that it be a superb teaching facility while also being safe, healthy, durable, resource efficient, and adaptable to the future. Nearly four years of occupancy suggest that the building is successfully meeting these goals. Oakes Hall shows that a green building can be practical, cost-effective, and comfortable while providing quite significant environmental benefits.

I was the environmental design consultant for the project, and worked closely with Dan Lewis P.E. and his partners at Kohler & Lewis on the mechanical systems, and with Rolf Kielman AIA at Truex Cullins and Partners and David Boehm P.E. at Engineering Ventures on the building design and envelope.

### **System Description**

The design approach integrates a superinsulated building envelope, highly efficient HVAC systems, and non-toxic materials to create a healthy indoor environment while consuming much less energy and water than the typical building. The principal energy load in a classroom building is ventilation air. The key element of the Oakes Hall HVAC system is a central ventilation system with an enthalpy recovery wheel and variable speed drives. It sends 100% outdoor air to a classroom when it is occupied, and no outdoor air when it is unoccupied. This design strategy cuts thermal energy consumption by a factor of four.



The superinsulated envelope, which consists of stress-skin foam panels over a structural steel frame, triple glazed low-e windows with insulated sash and frames, and field-tested airtight construction detailing, eliminated the need for perimeter heating. Composting toilets serve the two upper levels of the building.

### **Energy Efficiency Strategies**

Expanded polystyrene foam core stress skin panels (R-24 wall, R-38 roof) enclose the structural steel frame. The insulation is continuous from sub-slab to ridge with no thermal bridges. Fiberglass windows with low-e triple glazing are used throughout. Airtightness was blower-door tested (6172 CFM50), and the thermal shell follows the exterior skin of the building. This strategy ensures that all mechanical/electrical/communications/fire protection services are completely within the conditioned envelope.

Ventilation in each space is initiated by the users with a push button, and is turned off by an occupancy sensor. A central enthalpy wheel recovers about 80% of heat and moisture. Full air-side economizer cooling (cooling the building with outdoor air when its temperature is sufficiently low) is available, highly usable in the cold Vermont climate. Because southwest corridors are not occupied as heavily as classrooms, they are not mechanically cooled. Instead an exhaust fan and several automatically-opened windows accomplish cooling (fan coil units were designed to allow them to be easily modified for cooling should this be desired later.)

Premium efficiency motors, variable frequency drives, and efficient blower wheels minimize electrical usage of the mechanical system, and having outdoor air quantity track building occupancy significantly reduces blower energy. The central air handler was built without a supply blower. Instead an external blower takes advantage of the need to make a 90 degree turn in airflow immediately after leaving the unit. This enabled a more optimized blower selection and reduced supply fan horsepower from 10 to 7½.



Four modular, low-mass, sealed-combustion, oil-fired boilers replaced a single aging boiler in an adjoining building and heat both buildings, yielding savings in the adjoining building while providing an efficient heating plant for Oakes Hall. A DDC (direct digital controls) control system allows monitoring of performance and permits easy system adjustments.

Electronically ballasted T8 and compact fluorescent lamps with occupancy sensors light the building. Most classrooms are lit by fixtures that have three T8 lamps; switches allow the use of one, two, or three lamps so that light levels can be tailored to need. Southwest corridors have photosensors which turn lights off when daylighting is adequate.

### **Performance**

Annual fuel oil consumption is approximately 3,500 gallons, or about 0.15 gallon per square foot (about 20,600 BTU/ft<sup>2</sup>). Electrical consumption is approximately 98,900 kWh/year, or 4.2 kWh per square foot. These figures are substantially below typical buildings of this type, especially in this climate.

### **Indoor Environmental Quality Strategies**

There is no on-site combustion or fuel storage except for a small, sealed-combustion propane-fired fireplace in the lounge. This reduces chances for contamination from combustion products or fuel leaks. Biological contamination is prevented through envelope design—no thermal bridges, proper drainage and weather barriers, minimal carpet—and HVAC design, providing for adequate condensate collection from chilled water coils. The moisture recovered in the enthalpic recovery ventilation system stabilizes relative humidity, producing higher relative humidity in the winter and lower in the summer. Ventilation air is filtered but not recirculated, since occupied rooms receive

100% outdoor air (at a rate of 20 cubic feet per minute per occupant).

We took great care to specify low toxicity materials, adhesives, and finishes. Most rooms have natural linoleum flooring, which is easily cleaned and does not harbor biological contaminants. The superior envelope and a zone per room strategy ensure thermal comfort. Operable windows contribute to occupant satisfaction. The classrooms have a comfortable visual environment due to modest daylighting, high CRI (color rendering index) artificial lighting, light-colored surface finishes, and glare-free design.

### **Innovative Aspects**

The building's ventilation scheme is probably its most creative and novel feature. Occupants initiate ventilation air manually. Approximately ten minutes after a room is vacated, the occupancy sensors not only turn lights off but also outdoor air to the room. This strategy was devised to reduce the incidence of "false ons" caused by casual entry into a classroom, and also to enable occupants to make their own decision as to whether mechanical ventilation is needed. For example, when a few students work on homework in a 100-seat classroom, they can decide to call for mechanical ventilation (by pushing a button labeled Push for Ventilation adjacent to the light switches), open windows, or do nothing. This strategy is working well.

Occupants also have the ability to alter a classroom's temperature setting by up to 3 degrees F. This change is permitted to remain for a timed period, currently set at one hour. This allows some user fine-tuning of thermal comfort without allowing the building to go completely out of control.

To make it easy for users to control their environment, we laid out the controls (temperature, ventilation, lighting) identically in each classroom, and labeled them with permanent, easy-to-read labels. Each light switch is labeled as to which lights it controls. A brief set of instructions on the temperature and ventilation controls is posted adjacent to them.

Composting toilets serve the two upper levels and conventional low-flow flush toilets serve the lowest level, where ledge conditions made composting toilets impractical. We removed some water fixtures from adjacent buildings in recognition that the new building added no additional population on campus. This strategy has actually reduced the combined water demand of the Old Classroom Building and Oakes Hall by almost 50,000 gallons annually. The new building used just 5,100 gallons during its first year.

The four largest classrooms each have two space conditioning coils, permitting a room to be divided into two smaller classrooms in the future. But even now, this feature helps maintain dehumidification effectiveness at off-peak sensible loads during the cooling system. One coil has its supply water temperature raised while the other receives full chilled water. 80% of dehumidification is retained at 50% sensible load. Coils are alternated to maintain even conditions across the room.

We sized the air-cooled chiller plant carefully to serve the projected occupancy of the

building, which is such that all classrooms are never simultaneously occupied. The result is just a 23-ton chiller to serve a 23,500 square foot building. To account for unanticipated future needs, the interior liquid side heat exchanger and piping to it was sized to accommodate a second identical chiller.

### **Cost Effectiveness**

The hard construction cost of the building was about \$115 per square foot—very competitive with similar buildings. The estimated net present value of the energy savings over 20 years is \$275,000. The robust durable envelope, durable mechanical components, and no perimeter heating system minimize operating and maintenance costs. Our integrated systems design approach considered the envelope design, glazing choices, lighting design, and mechanical system together to create a comfortable, healthy, resource-efficient building which pleases the users and satisfies the original goals while staying within budget.

### **Environmental Impact**

Annual energy savings predicted by computer simulation over a code-conforming base building are 80,399 kWh and 10,054 gallons of fuel oil. The estimated annual avoided emissions are 160 tons of CO<sub>2</sub> and .6 tons each of SO<sub>2</sub> and NO<sub>x</sub>.

In addition, as noted above, campus water use has declined significantly. We also feel that Oakes Hall benefits the environment by educating building users and visitors to the environmental impacts of buildings and their means of mitigation. The building features displays about its technology and additional printed material is available. Information about the building is also hosted on the Vermont Law School web site ([www.vermontlaw.edu](http://www.vermontlaw.edu)).

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