Design Features
For
High Performance Classrooms
At Mount Angel Abbey's Academic Center

Insulation

Feature: Higher than normal levels of insulation are used to retain heat during the winter. During the summer, the insulation keeps heat outside and the interior concrete cool.

Description: The roof was specified with a minimum R-28 (4 inches of polyisocyanurate board insulation). Walls have an R-value of 23 (R-10 rigid XPS in the masonry cavity with R-13 fiberglass blankets inside the stud cavities).[1] It should be noted that the rigid insulation is placed outside of the studs which creates a higher insulation value than having more insulation in the stud depth (due to less heat transfer through the studs). In addition, the weather barrier is located outside of the stud cavity.

Note: Marion County required the submittal of an Alternate Means and Methods form along with dew point calculations to show that condensation would occur on the exterior of this barrier.

Thermal Mass

Feature: Materials that absorb and retain heat and "coolth" are used to moderate temperature swings (between day and night) within the classroom. The concrete or other types of thermal mass create a "thermal lag" where heat and coolth are adsorbed and then later released.

Description: During winter months, concrete absorbs and retains excess heat generated from students and lighting. At night, the heat is slowly released back into the space. During the summer months, low nighttime temperatures cool the concrete. This coolth is slowly released into the space the following day thus allowing students to "feel" cool during the day.

The concrete slab on grade is 4-inch thick under the classrooms. Above the classroom, there is 5 inches of concrete over a metal roof decking.[2] The concrete is insulated.

Heating and Ventilation

Feature: Energy recovery ventilators combined with thermal mass and high insulation values are used to heat the classroom.

Description: The thermal mass and high insulation levels retain the heat that is generated by electric lights, daylighting, and the students. To meet minimum ventilation rate requirements, each classroom has energy recovery ventilators (ERVs)—fan units with heat exchangers. The heat exchanger transfers heat from the exhaust air to the incoming fresh air. In the summer, cooler exhaust air reduces the temperature of the incoming air. These units operate when CO^2 sensors indicate that people are present and when natural ventilation is not feasible due to outdoor air temperatures.

The fan speed on the ERVs is automatically adjusted based on CO^2 levels (which varies depending on the number of people in the room).

As a precaution, panel radiators (using hot water) were installed in the classroom. Their usage, however, should be minimal due to the other heating and ventilation features incorporated into the design of the classroom.

---

[1] Code insulation levels are R-19 roof and R-7 for walls.

[2] A gap between ceiling panel and wall allows hot or cold air to circulate across the concrete (thermal mass) in the ceiling. Note: Carpet and other coverings reduce the effectiveness of thermal mass.

Cooling

Feature: Natural ventilation combined with thermal mass and high insulation values are used to cool the classroom at night (and keep them cool during the day), without the need for mechanical air conditioning.

Description: Natural ventilation uses the buoyancy of air (i.e., hot air rises) to ventilate the classroom at night. The cooler outside air enters the classroom and removes the heat from the thermal mass as it rises and leaves through the roof vents. The concrete (in the floor and ceiling) remains cool throughout the day because of the high insulation values. This “night flush” feature combines automated and manual dampers to cool the thermal mass. The automatic dampers are located above the windows (and in the roof vent). Occupants can operate manual dampers (on either side of the window) to increase air circulation. In addition, the turbine ventilators on the roof above each classroom increases the amount of cool air passing through the classroom.

During extreme weather conditions (hot days and warm nights), ceiling fans can be turned on to increase air circulation which provides additional comfort for the students.

Daylighting

Feature: Superior daylighting is achieved using a large centrally located skylight, a sloped ceiling, and a reflector hanging below the skylight.

Description: Skylights (manufactured by CPI) are installed in each classroom. These skylights have louvers between the glass plates that are controlled by light sensors.[3] The louvers automatically adjust to maintain a pre-set light level in the classroom.

A custom aluminum metal fabricated reflector hanging below the skylight reflects daylight onto the sloped acoustical ceiling that reflects the light back down into the room.[4] This custom fabricated unit is made of triangular aluminum tubes and it has fewer opening (that allow light to pass through) in the center and more openings at the ends near the walls. However, the very center of the reflector (which is the middle of the room) is completely open. This configuration (of skylight with controls, reflector, sloped ceiling) provides a uniform light distribution by allowing some light to pass directly into the room while reflecting some of the light from the skylight onto the ceiling that is then reflected into the room.

The design goal for foot-candle (fc) level is 30.

Extra benefit: Because of the lighting configuration, the light levels on the walls are approximately the same as the lighting levels on the floor. This result gives the room a very bright feel – brighter than the design goal of only 30 fc.

Electrical Lighting

All classrooms have single T5HO fixtures in four-foot lengths. LPD = 0.96 W/ft^2.
Electric light fixtures incorporate dimming and photo controlled sensors.
Occupancy sensors for lighting control.
The design foot-candle (fc) level is 30.

Miscellaneous

[3] The skylight is a polycarbonate panel with a square tubular cross-section. Half-circle shaped polycarbonate louvers rotate within the panel itself. Also, there are two light sensors that provide the louver control system with information on the amount of light in the classroom and the exterior of the building.
[4] If the reflector were not present, then it would appear brighter directly under the skylight and dim near the perimeter.

Brick veneer facade except where curtainwall window systems occur.
Setpoints: Heating – 70 degrees F occupied and 62 degrees F unoccupied, cooling – 81 degrees F occupied and 85 degrees F unoccupied. Note: Typically, the room's temperature is not 81 degrees F. The 81 degrees F temperature is a worst case and occurs within weather conditions (i.e., hot day followed by warm night).
ERVs uses an enthalpy wheel
Full condensing boiler

Acoustics
db level to be determined.

Details of 30' by 30' Classroom
ERV unit (manufactured by Cook) is a 420 CFM unit with 1/2 HP motor.
Skylight is designed to be approximately 10'-10" x 12'-7" (inside dimension).
Daylight reflector is 14'-4" x 16'-4" at its furthest extremes. It is supported on a frame that resides within that dimension. It has a clear rectangular opening (no aluminum tubes) in the middle that measures 2'-4" x 4'-4". There are three tiers of aluminum tubing at increased openness as they extend out from the middle. Custom fabricated by Hanset Stainless of Portland.
Skylight slope is 2:12 and they are on a curb made of metal stud work that puts them up one foot above roofline.
A total of 14 single T5HO fixtures are configured in two sets of twelve foot lengths and two sets of sixteen foot lengths. (0.96 W/ ft2).

Potential Design Variations for K-12 Classrooms
Increase insulation levels
Install electric resistant heat (in duct or on wall) for back-up heating rather than hydronic.
ERV uses flat plate heat exchanger not enthalpy wheel
Control ERVs with occupancy sensors.
Install indirect evaporative cooling, if needed
Install electric lights on top of hanging reflector (to take advantage of the ceiling configuration to redirect light on the sloped ceiling to provide uniform lighting in the classroom).
Change reflector materials
Use translucent panel skylight (e.g., Kalwall) w/ internal dampers

Costs (from energy model)
Incremental costs are for the entire building. Non-classroom areas are passively heated and cooled. Incremental costs for just the classroom could not be determined.

Improved building shell	1.30 $ / ft^2	(Increased insulation levels)
Daylighting	7.09 $ / ft^2	(Skylight, reflector, lighting controls)
HVAC	-2.00 $ / ft^2	(Baseline system: VAV with hydronic reheat)
ERVs	1.76 $ / ft^2	
Sub-Total	8.15 $ / ft^2	
Incentive	3.33 $ / ft^2	
TOTAL	***4.82*** $ / ft^2	

Incentives include cash rebates from the Energy Trust of Oregon (ETO) and 35 percent Business Energy Tax Credit from the Oregon Department of Energy.

Energy Savings (from energy model)

Energy Efficiency Measure	Savings			Incremental Cost	Simple Payback
	kWh	Therms	Cost		
Improved Building Shell	10,497	3,215	$ 3,933	$ 27,305	6.9
Daylighting & HVAC	115,984	2,252	$ 11,415	$ 144,267	12.6
Total	126,481	5,467	$ 15,348	$ 171,572	11.2
Total - Incentive ($70K)	126,481	5,467	$ 15,348	$ 101,670	6.6

Note: $70K incentive includes the incentive for a full condensing boiler

Proposed EUI = 24,480 (baseline is 73,200)
Efficiency over code: 61%
Cost savings over code: 59%

Lessons learned

An important element to focus on includes the controls for the skylights; the implications of tying different control systems together; and placing the weather barrier outside of stud work. The Mount. Angel classroom prototype was a critical design tool. Its construction and testing allowed for a more complete realization of the design concepts used at the Mount Angel Academic Center.

Design Team for Mount Angel Abbey Academic Center

Architect: Kent Duffy, SRG Partnerships
Mechanical and electrical: Mike Hatten, Solarc
Energy modeling: Mike Hatten, Solarc
Daylighting, Natural Ventilation Modeling, Sustainability Consultant:
G.Z. “Charlie” Brown
Energy Studies in Buildings Laboratory,
University of Oregon

Additional Support for Mount Angel Abbey Prototype Classroom

CPI International Inc.
Energy Studies in Buildings Laboratory
Mount. Angel Abbey
O’Brien Constructors LLC
SRG Partnership, Inc.

Design Team for High Performance Classroom Concept

G.Z. “Charlie” Brown, Energy Studies in Buildings Laboratory, University of Oregon
Mike Hatten, Solarc
Heinz Rudolf, BOORA Architects
BetterBricks provided the funding for initial classroom design